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# TONER AND IMAGE-FORMING APPARATUS USING THE SAME

## FIELD OF THE INVENTION

5       The present invention relates to the technical field of toners used for forming images of electrostatic images in electrophotography, electrostatic recording and electrostatic printing etc. by development to toner images and heat-fixing the toner images, and also relates to  
10 image-forming apparatus, e.g., copying machines, printers and facsimiles using the toner.

## BACKGROUND OF THE INVENTION

15       As electrophotography, a method of forming an electrostatic charge image on a photosensitive material comprising a photoconductive substance, developing the electrostatic charge image by a toner carried on a developing roller, transferring the toner image developed  
20 on the photosensitive material directly to a recording medium, e.g., paper, or via an intermediate transfer substance, and fixing the toner image on the recording medium by a fixing roller, e.g., a heating roller, on the recording medium, e.g., paper, by press-heating is known.  
25       The toners used in this method are required not to

bring about a so-called low temperature or hot offset, i.e., the adhesion of melted toner on a heating roller, and also required to have excellent fixing ability such as great fixing strength of the toner image fixed on a recording medium.

In fixing using a heating roller, as the factors which control the fixing ability and the offset resistance of the toners; it is well known that the storage modulus  $G'$  and the loss modulus  $G''$  in dynamic viscoelastic characteristics of a toner have influence. Storage modulus  $G'$  and loss modulus  $G''$  are viscoelastic characteristics of a substance having general viscoelasticity defined by complex elastic modulus in vibration experiment, and the real number part of complex elastic modulus is called storage modulus  $G'$  and the imaginary number part is called loss modulus  $G''$ , specifically, storage modulus is an index showing the degree of the elasticity of a toner and loss modulus is an index showing the degree of viscosity. The dynamic viscoelastic characteristics are characteristics having a temperature-dependency varying according to the temperature, a frequency-dependency varying according to the frequency, and a strain-dependency varying according to the strain, i.e., characteristics showing a linear region of behaving linearly according to temperature, frequency and strain, or a nonlinear region of behaving nonlinearly.

It is proposed to improve the fixing ability, offset resistance and blocking resistance of a toner image by expressing the melting state of a toner at fixing time in such dynamic viscoelastic characteristics of temperature-dependency of a toner (e.g., refer to patent literature 1).

That is, the toner in this proposal is the toner containing binder resins, colorants and release agents, and the proposal intends to improve low temperature fixing ability, offset resistance and blocking resistance of the toner by setting the temperature of the time when the ratio of loss modulus to storage modulus ( $G''/G' = \tan\delta$ ) becomes 1.0 at the range of from 55 to 70°C, the elastic modulus at that time at  $1.5 \times 10^8$  Pa or less, the ratio of storage modulus  $G'$  (40) to storage modulus  $G'$  (50) ( $G' (40)/G' (50)$ ) at from 1.5 to 5.0, the ratio of storage modulus  $G'$  (50) to storage modulus  $G'$  (60) ( $G' (50)/G' (60)$ ) at from 3 to 20, the ratio of storage modulus  $G'$  (70) to storage modulus  $G'$  (100) ( $G' (70)/G' (100)$ ) at from 50 to 250, and the ratio of storage modulus  $G'$  (110) to storage modulus  $G'$  (140) ( $G' (110)/G' (140)$ ) at from 2 to 20.

[Patent literature 1]

JP-A-10-171156 ("Abstract" etc.) (the term "JP-A" as used herein means an "unexamined published Japanese patent application").

§ . In the above-described fixation by heating, toners  
come to show the behavior of a linear region (L1) before  
fixing nip (inlet), the behavior of a nonlinear region (NL)  
5 at fixing nip part, and the behavior of a linear region  
(L2) at the outlet of fixing nip.

However, in the toner disclosed in patent literature  
1, the dynamic viscoelasticity of temperature-dependency  
measured in a linear region is used. In the fixation by  
10 heating, as described above, mere application of the  
dynamic viscoelasticity of temperature-dependency measured  
in a linear region to the toner showing a linear region  
(L1)-a nonlinear region (NL)-a linear region (L2) behavior  
is not conformable to actual behavior of the toner at the  
15 time of heat-fixation. Therefore, it cannot be said that  
low temperature fixing ability and offset resistance of the  
toner are sufficiently and effectively improved.

Thus, it cannot be said that sufficient and effective  
improvement has been done by conventional improvement of  
20 fixing characteristics of toners, and there is plenty of  
scope for improvements of low temperature fixing ability  
and offset resistance of toners.

The present invention has been done in view of these  
circumstances.

## SUMMARY OF THE INVENTION

An object of a first aspect of the present invention (hereinafter referred to as "first invention") is to  
5 provide a toner which can effectively improve low temperature fixing ability and offset resistance of a toner by using dynamic viscoelastic characteristics more conformable for actual toner behavior in fixation by heating.

10 Another object of the first invention is to provide an image-forming apparatus capable of forming a high quality image while enhancing low temperature fixing ability and preventing offset of a toner.

An object a second aspect of the present invention  
15 (hereinafter referred to as "second invention") is to provide a toner which can effectively improve fixing ability and offset resistance of a toner by using dynamic viscoelastic characteristics more conformable to actual toner behavior in fixation by heating.

20 Another object of the second invention is to provide an image-forming apparatus capable of forming a high quality image while enhancing fixing ability, realizing oil-less fixation and preventing offset of a toner.

The present inventors made extensive investigations  
25 to solve the above-described problems and found that the

problems can be solved by providing a toner comprising a binder resin and at least a colorant, wherein the toner has a specific storage modulus and/or a specific loss modulus in step strain measurement of from a linear region to a nonlinear region of viscoelastic characteristics. Thereby, dynamic viscoelastic characteristics of the toner are effectively utilized in fixation by heating, thus a toner more conformable to actual behavior of toner can be obtained.

That is, the above-described objects of the present invention have been achieved by providing the followings:

The first invention mainly relates to the following items.

(1) A toner comprising a binder resin and at least a colorant, wherein the toner has a storage modulus ( $G' (L1)$ ) in a linear region and a storage modulus ( $G' (NL)$ ) in a nonlinear region at 180°C, in step strain measurement of from a linear region to a nonlinear region of viscoelastic characteristics, satisfying the relationships of

$G' (L1)/G' (NL)$  is from 5 to 20, and  
 $G' (NL)$  is from 100 to 400 dyn/cm<sup>2</sup>.

(2) The toner according to item 1, wherein the toner contains a release agent in an amount of 4 parts by weight or less per 100 parts by weight of the binder resin.

(3) An image-forming apparatus comprising at least:

an image carrier on which an electrostatic latent image is formed;

a developing unit which develops the electrostatic latent image on the image carrier to form a toner image by  
5 a toner;

a transferring unit which transfers the toner image on the image carrier to a recording medium; and

a fixing unit which fixes the toner image transferred to the recording medium by heating,

10 wherein the toner is the toner according to items 1 or 2,

wherein the fixing unit has oil-less two rollers.

The second invention mainly relates to the following items.

15 (4) A toner comprising a binder resin and at least a colorant, wherein the toner has a storage modulus ( $G' (L2)$ ) in a linear region at 180°C, in step strain measurement of from a nonlinear region to a linear region of viscoelastic characteristics, of from 400 to 2,000 dyn/cm<sup>2</sup>.

20 (5) The toner according to item 4, wherein the toner has a ratio of the storage modulus ( $G' (L2)$ ) to the storage modulus ( $G' (NL)$ ) in a nonlinear region  $G' (L2)/G' (NL)$  at 180°C, in step strain measurement of from a nonlinear region to a linear region of viscoelastic characteristics,  
25 of from 3 to 8.



(6) The toner according to item 4, wherein the toner contains a release agent in an amount of 4 parts by weight or less per 100 parts by weight of the binder resin.

(7) An image-forming apparatus comprising at least:

5 an image carrier on which an electrostatic latent image is formed;

a developing unit which develops the electrostatic latent image on the image carrier to form a toner image by a toner;

10 a transferring unit which transfers the toner image on the image carrier to a recording medium; and

a fixing unit which fixes the toner image transferred to the recording medium by heating,

wherein the toner is the toner according to any one  
15 of items 4 to 6,

wherein the fixing unit has oil-less two rollers.

#### BRIEF DESCRIPTION OF THE DRAWINGS

20 Fig. 1 is a drawing typically showing an example of the fixing unit of an image-forming apparatus to which the toner of the first invention is applied.

Fig. 1 is a drawing showing an example of the behavior of the toner of the present invention having the  
25 dynamic viscoelasticity of temperature-dependency before

fixing nip at fixing nip part, and at the outlet of fixing nip of a heating fixing unit.

5

#### DETAILED DESCRIPTION OF THE INVENTION

The toner according to the present invention has a dynamic viscoelastic characteristic showing the behavior of a linear region (L1) before fixing nip (inlet), the behavior of a nonlinear region (NL) at fixing nip part, and the behavior of a linear region (L2) at the outlet of fixing nip. This dynamic viscoelastic characteristic is a characteristic of deformation dependency varying according to strain. For example, in the step strain measurement of a viscoelastic characteristic at 180°C as shown in Fig. 2, in the toner in Experimental Examples described later, storage modulus  $G'$  dyn/cm<sup>2</sup> and loss modulus  $G''$  dyn/cm<sup>2</sup> show respectively the behaviors of linear  $G'$  (L1) dyn/cm<sup>2</sup> and  $G''$  (L1) dyn/cm<sup>2</sup> until 300 sec after starting the measurement, and in the next period of from 300 sec to 600 sec, storage modulus  $G'$  dyn/cm<sup>2</sup> and loss modulus  $G''$  dyn/cm<sup>2</sup> show respectively the behaviors of nonlinear  $G'$  (NL) dyn/cm<sup>2</sup> and  $G''$  (NL) dyn/cm<sup>2</sup> with the increase of the amount of strain, and in the next period of from 600 sec to 900 sec, storage modulus  $G'$  dyn/cm<sup>2</sup> and loss modulus  $G''$  dyn/cm<sup>2</sup> show respectively the behaviors of linear  $G'$  (L2) dyn/cm<sup>2</sup> and  $G''$

(L2) dyn/cm<sup>2</sup>, by making the strain amount the same with the strain amount L1.

A viscoelasticity regulated in the present invention can be provided by regulating molecular weight, molecular weight distribution, degree of cross-linkage and molecular structure of a resin in the toner of the present invention.

In step strain measurement of from a linear region to a nonlinear region of viscoelastic characteristics, the binder resin of the toner of the first invention is prepared so that the storage modulus ( $G' (L1)$ ) in a linear region and the storage modulus ( $G' (NL)$ ) in a nonlinear region at 180°C satisfy the relationship:

$G' (L1)/G' (NL)$  is from 5 to 20, and

$G' (NL)$  is from 100 to 400 dyn/cm<sup>2</sup>.

In the toner of the first invention having such a constitution, a linear region and a nonlinear region of dynamic viscoelastic characteristics of the strain dependency of the toner are effectively utilized in fixation by heating, thus a toner more conformable to actual behavior of toner can be obtained.

In that case, when  $G' (NL)$  is in the range of from 100 to 400 dyn/cm<sup>2</sup> and the ratio  $G' (L1)/G' (NL)$  is less than 5, the elasticity becomes too low and there arises a problem in offset resistance. While when  $G' (NL)$  is in the range of from 100 to 400 dyn/cm<sup>2</sup> and the ratio  $G' (L1)/G'$

(NL) is more than 20, the elasticity becomes too high and there arises a problem in low temperature fixing ability.

Therefore, according to the toner of the first invention, the melting of the toner in fixing nip is performed smoothly and it becomes possible to effectively improve low temperature fixing ability and offset resistance of the toner.

In particular, when the content of a release agent is more than 4 parts by weight per 100 parts by weight of the binder resin, transparency is hindered, so that transparency can be improved by setting the content of a release agent at 4 parts by weight or less per 100 parts by weight of the binder resin.

The toner of the second invention is prepared so that the storage modulus ( $G'$  (L2)) in a linear region at 180°C is from 400 to 2,000 dyn/cm<sup>2</sup> in step strain measurement of from a nonlinear region to a linear region of viscoelastic characteristics.

In the toner of the second invention having such a constitution, the characteristics of from a nonlinear region to a linear region of dynamic viscoelastic characteristics of the strain dependency of the toner are effectively utilized in fixation by heating, thus a toner more conformable to actual behavior of toner can be obtained.

In that case, when  $G' (L2)$  is less than 400, the elasticity becomes too low, and there arises a problem in offset resistance.

Accordingly, by using the toner of the second invention, elasticity after transiting fixing nip can be ensured and hot offset resistance can be effectively improved.

In particular, when the ratio of the storage modulus ( $G' (L2)$ ) to the storage modulus ( $G' (NL)$ ) in a nonlinear region in step strain measurement of from a nonlinear region to a linear region of viscoelastic characteristics at 180°C,  $G' (L2)/G' (NL)$ , is from 3 to 8, fixing ability is improved and at the same time good hot offset resistance can be obtained.

In that case, when  $G' (L2)$  is in the range of from 400 to 2,000 dyn/cm<sup>2</sup> and the ratio  $G' (L2)/G' (NL)$  is less than 3, there arises a problem in fixing strength. While when  $G' (L2)$  is in the range of from 400 to 2,000 dyn/cm<sup>2</sup> and the ratio  $G' (L2)/G' (NL)$  is more than 8, offset resistance is deteriorated.

Further, when the content of a release agent in a toner is more than 4 parts by weight per 100 parts by weight of the binder resin, transparency is hindered, so that transparency can be improved by setting the content of a low melting substance at 4 parts by weight or less.

As the binder resins which are used in the invention  
and capable of controlling viscoelastic characteristics in  
a fixing region, binder resins having both a crystalline  
region and an amorphous region are preferably used, e.g.,  
5 resins having a urethane bond and a urea bond, resins  
comprising the blend of a crystalline polyester resin and  
an amorphous polyester resin, and polyester resins  
comprising a block copolymer of a crystalline part and an  
amorphous part, are exemplified. Amorphous polyester and  
10 block polyester are particularly preferably used as the  
binder resins.

Viscoelasticity can also be controlled with the  
compositions which are designed so that a polymerization of  
a binder resin in the toner progresses when heat energy is  
15 given in the range of fixing temperature, and the binder  
resin is crosslinked and the molecular weight increases by  
previously controlling the polymerization of the binder  
resin in conjunction with blending a polymerization  
initiator and/or a crosslinking initiator which exhibit  
20 their functions when heat energy higher than the prescribed  
quantity is given at fixing time.

The binder resin for use in the toner of the present  
invention comprises a polymer, and a polymer generally has  
a property of showing viscoelastic characteristics in a  
25 molten state of a toner. When a certain strain is given,

the stress of the toner is relaxed with the time  $t$  (sec) in the stress relaxation measurement described later, so that the relaxation modulus  $G(t)$  [Pa], which is one of viscoelastic characteristics, shows a property of lessening  
5 with the relaxation time  $t$  (sec).

The toner of the invention is particularly described below with binder resins using well-known polyester resins as a binder resin in a toner having above-described viscoelasticity as an example.

10 The toner of the example comprises toner particles comprising a polyester resin containing a colorant and a charge controlling agent kneaded and pulverized. And the binder resin has functions of retaining colorant particles in toner particles, being softened by the heat and pressure  
15 of fixing rollers in fixation, and adhering the toner particles to a transfer material, e.g., paper. However, when the molecular weight of the binder resin is lowered and the softening temperature is lowered for the purpose of low temperature fixation, the reductions of glass  
20 transition temperature, strength, the retention of colorant, offset resistance, the strength of fixed images, and the storage stability are brought about.

#### Constitutional components of toner

25 The toner of the present invention can be

manufactured with materials containing at least a resin as the main component (hereinafter sometimes referred to as merely "a resin").

Each component of the materials for use in manufacturing the toner of the invention is described below.

1. Resin (binder resin)

The resins (binder resins) in the present invention mainly comprise polyester resins. The content of polyester resins in the resins is preferably 50 wt.% or more, and more preferably 80 wt.% or more.

In general, polyester resins consist of an alcohol component (including those having 2 or more hydroxyl groups) and a carboxylic acid component (including divalent or higher carboxylic acids and derivatives thereof).

As the alcohol components, those having 2 or more hydroxyl groups can be used, such as chain diols, e.g., ethylene glycol, 1,3-propanediol, 1,2-propylene glycol, 1,3-propylene glycol, 1,4-butanediol, diethylene glycol, 1,5-pentanediol, 1,6-hexanediol, dipropylene glycol, triethylene glycol, tetraethylene glycol, 1,2-propanediol, 1,3-butanediol, 2,3-butanediol, neopentyl glycol (2,2-dimethylpropane-1,3-diol), 1,2-hexanediol, 2,5-hexanediol, 2-methyl-2,4-pentanediol, 3-methyl-1,3-pentanediol, 2-ethyl-1,3-hexanediol, 2-butyl-2-ethyl-1,3-propanediol, 2,4-



diethyl-1,5-pentanediol, polyethylene glycol, polypropylene glycol, and polytetramethylene glycol, cyclic diols, such as alkylene oxide adducts of bisphenol A, e.g., polyoxypropylene(2.2)-2,2-bis(4-hydroxyphenyl)-propane, 5 polyoxypropylene(3.3)-2,2-bis(4-hydroxy-phenyl)propane, polyoxyethylene(2.0)-2,2-bis(4-hydroxy-phenyl)propane, polyoxypropylene-(2.0)-polyoxy-ethylene(2.0)-2,2-bis(4-hydroxyphenyl)propane, and polyoxypropylene(6)-2,2-bis(4-hydroxyphenyl)propane, 2,2-bis(4-hydroxycyclohexyl)propane, 10 alkylene oxide adducts of 2,2-bis(4-hydroxycyclohexyl)propane, 1,4-cyclohexanediol, 1,4-cyclohexanedimethanol, hydrogenated bisphenol A, and alkylene oxide adducts of hydrogenated bisphenol A, and trivalent or higher polyhydric alcohols, e.g., sorbitol, 15 1,2,3,6-hexanetetrol, 1,4-sorbitan, pentaerythritol, dipentaerythritol, tripentaerythritol, 1,2,4-butanetriol, 1,2,5-pentanetriol, glycerol, 2-methylpropanetriol, 2-methyl-1,2,4-butanetriol, trimethylolethane, trimethylolpropane, and 1,3,5-trihydroxymethylbenzene are 20 exemplified.

The alcohol components mainly comprising aliphatic diols having two hydroxyl groups are particularly used in the present invention. Further, the alcohol components may comprise aliphatic alcohols having three or more hydroxyl 25 groups.

As the aliphatic alcohols having two or more hydroxyl groups, such as chain diols, e.g., ethylene glycol, 1,3-propanediol, 1,2-propylene glycol, 1,3-propylene glycol, 1,4-butanediol, diethylene glycol, 1,5-pentanediol, 1,6-hexanediol, dipropylene glycol, triethylene glycol, tetraethylene glycol, 1,2-propanediol, 1,3-butanediol, 2,3-butanediol, neopentyl glycol (2,2-dimethylpropane-1,3-diol), 1,2-hexanediol, 2,5-hexanediol, 2-methyl-2,4-pentanediol, 3-methyl-1,3-pentanediol, 2-ethyl-1,3-hexanediol, 2-butyl-2-ethyl-1,3-propanediol, 2,4-diethyl-1,5-pentanediol, polyethylene glycol, polypropylene glycol, and polytetramethylene glycol, and cyclic diols, e.g., 2,2-bis(4-hydroxycyclohexyl)propane, alkylene oxide adducts of 2,2-bis(4-hydroxycyclohexyl)-propane, 1,4-cyclohexanediol, 1,4-cyclohexanedimethanol, hydrogenated bisphenol A, and alkylene oxide adducts of hydrogenated bisphenol A are exemplified.

Thus in the present invention, the alcohol component mainly comprises aliphatic diol, preferably 50 mol% or more of aliphatic diol, and more preferably 80 mol% or more of aliphatic diol.

As the carboxylic acid components, e.g., divalent or higher carboxylic acids, and derivatives thereof (e.g., acid anhydrides and lower alkyl esters) can be used, e.g., o-phthalic acid (phthalic acid), terephthalic acid,

isophthalic acid, succinic acid, adipic acid, sebacic acid, azelaic acid, octylsuccinic acid, cyclohexanedicarboxylic acid, fumaric acid, maleic acid, itaconic acid, trimellitic acid pyromellitic acid and derivatives of these acids (e.g., anhydrides and lower alkyl esters) are exemplified.

In the present invention, it is particularly preferred that the carboxylic acid component comprise divalent dicarboxylic acid.

The examples of divalent carboxylic acids include e.g., o-phthalic acid (phthalic acid), terephthalic acid, isophthalic acid, succinic acid, adipic acid, sebacic acid, azelaic acid, octylsuccinic acid, cyclohexanedicarboxylic acid, fumaric acid, maleic acid, itaconic acid, and derivatives of these acids (e.g., anhydrides and lower alkyl esters).

In the present invention, it is particularly preferred to use polyester resins containing block polyesters and amorphous polyesters as described later. These polyester resins are described in detail below.

#### 1-1. Block polyester:

Block polyester comprises a block copolymer having a crystalline block obtained by condensation of an alcohol component and a carboxylic acid component, and an amorphous block that is lower in crystallinity than the crystalline

block.

(1) Crystalline block

As compared with amorphous blocks or amorphous  
5 polyesters, crystalline blocks are high in crystallinity.  
That is, the structure of molecular arrangement of  
crystalline blocks is strong and stable as compared with  
those of amorphous blocks or amorphous polyesters.  
Therefore, crystalline blocks contribute to the elevation  
10 of the strength of a toner as a whole. As a result, the  
toner finally obtained is strong in mechanical stresses and  
excellent in durability and storage stability.

Incidentally, highly crystalline resins generally  
have a so-called sharp melt property as compared with low  
15 crystalline resins. That is, highly crystalline resins  
have a property of exhibiting a sharp figure of endothermic  
peak as compared with low crystalline resins when subjected  
to the measurement of endothermic peak of melting  
temperature by differential scanning calorimetry (DSC).

20 On the other hand, as described above, crystalline  
blocks are high in crystallinity. Thus crystalline blocks  
have a function of imparting a sharp melt property to block  
polyesters. Therefore, the toner finally obtained can  
maintain excellent stability in figure at relatively high  
25 temperature (the temperature near the melting temperature

of the block polyester) at which the amorphous polyester described later is sufficiently softened. Accordingly, when these block polyesters are used, a sufficient fixing ability (fixing strength) can be obtained in a broad  
5 temperature range.

Further, crystals having high hardness and appropriate sizes can be precipitated in a toner by the presence of these crystalline blocks. Due to such crystals, the stability of the figure of a toner becomes excellent,  
10 in particular stable to mechanical stresses. In addition, by the presence of these crystals in a toner, external additives, which are described later, can be surely retained around the surfaces of toner particles (mother particles) (external additives can be effectively prevented  
15 from being buried in mother particles), so that the functions of external additives (functions of imparting e.g., excellent flowability and electrification property) can be sufficiently exhibited.

The constitutional components of crystalline blocks  
20 are described below.

As the alcohol components constituting crystalline blocks, those having two or more hydroxyl groups can be used, preferably diol components having two hydroxyl groups. As such diol components having two hydroxyl groups,  
25 aromatic diols having an aromatic cyclic structure and

aliphatic diols not having an aromatic cyclic structure are exemplified. As the aromatic diols, e.g., bisphenol A and alkylene oxide adducts of bisphenol A (e.g., polyoxypropylene(2.2)-2,2-bis(4-hydroxyphenyl)propane, 5 polyoxypropylene(3.3)-2,2-bis(4-hydroxyphenyl)propane, polyoxyethylene(2.0)-2,2-bis(4-hydroxyphenyl)propane, polyoxypropylene(2.0)-polyoxyethylene(2.0)-2,2-bis(4-hydroxyphenyl)propane, and polyoxypropylene(6)-2,2-bis(4-hydroxyphenyl)propane) are exemplified. As the aliphatic 10 diols, such as chain diols, e.g., ethylene glycol, 1,3-propanediol, 1,2-propylene glycol, 1,3-propylene glycol, 1,4-butanediol, diethylene glycol, 1,5-pentane-diol, 1,6-hexanediol, dipropylene glycol, triethylene glycol, tetraethylene glycol, 1,2-propanediol, 1,3-butanediol, 2,3- 15 butanediol, neopentyl glycol(2,2-dimethylpropane-1,3-diol), 1,2-hexanediol, 2,5-hexane-diol, 2-methyl-2,4-pentanediol, 3-methyl-1,3-pentanediol, 2-ethyl-1,3-hexanediol, 2-butyl-2-ethyl-1,3-propanediol, 2,4-diethyl-1,5-pentanediol, polyethylene glycol, polypropylene glycol, and 20 polytetramethylene glycol, and cyclic diols, e.g., 2,2-bis(4-hydroxycyclohexyl)propane, alkylene oxide adducts of 2,2-bis(4-hydroxycyclohexyl)-propane, 1,4-cyclohexanediol, 1,4-cyclohexanedimethanol, hydrogenated bisphenol A, and alkylene oxide adducts of hydrogenated bisphenol A, are 25 exemplified.

The diol components constituting crystalline blocks are not particularly restricted, but preferably at least a part of the diol components is aliphatic diol, more preferably aliphatic diol having 80 mol% or more of the diol components, and still more preferably aliphatic diol having 90 mol% or more. By this constitution, the crystallinity of block polyesters (crystalline block) can be heightened and the above effects can further be elevated.

The diol components constituting a crystalline block preferably have a straight chain molecular structure having from 3 to 7 carbon atoms, and diol components having hydroxyl groups at both terminals (diol represented by the formula:  $\text{HO}-(\text{C})_n\text{H}_n-\text{OH}$  (provided that  $n$  is from 3 to 7)). Since crystallinity increases and friction coefficient lowers by containing these diol components, the resisting properties against mechanical stresses are improved and excellent durability and storage stability can be obtained. The examples of such diols include, e.g., 1,3-propanediol, 1,4-butanediol, 1,5-pentanediol and 1,6-hexanediol. Of these diols, 1,4-butanediol is preferred. By containing 1,4-butanediol, the above effects become particularly conspicuous.

When 1,4-butanediol is contained as the diol component constituting a crystalline block, it is more preferred that the diol constituting a crystalline block

has 50 mol% or more of 1,4-butanediol, and still more preferred that the diol constituting a crystalline block has 80 mol% or more of 1,4-butanediol. By this constitution, the above effects become further conspicuous.

5 As the carboxylic acid components constituting a crystalline block, divalent or higher carboxylic acids and derivatives thereof (e.g., acid anhydrides and lower alkyl esters) can be used. Of those carboxylic acid components, divalent dicarboxylic acids and derivatives thereof are  
10 preferably used. The examples of dicarboxylic acids include, e.g., o-phthalic acid (phthalic acid), terephthalic acid, isophthalic acid, succinic acid, adipic acid, sebacic acid, azelaic acid, octylsuccinic acid, cyclohexanedicarboxylic acid, fumaric acid, maleic acid,  
15 itaconic acid, and derivatives of these acids (e.g., anhydrides and lower alkyl esters).

The dicarboxylic acid components constituting a crystalline block are not particularly restricted, but it is preferred that the dicarboxylic acid components at least  
20 partially have a terephthalic acid skeleton, more preferably 50 mol% or more of the dicarboxylic acid components have a terephthalic acid skeleton, and still more preferably 80 mol% or more of the dicarboxylic acid components have a terephthalic acid skeleton. By this  
25 constitution, the toner finally obtained comes to be a



toner well balanced in various characteristics required of the toner.

The content of the crystalline block in block polyester is not particularly restricted, but the content is preferably from 5 to 60 mol%, and more preferably from 10 to 40 mol%. When the content of the crystalline block is less than the lower limit, there is the possibility that the effect by containing the crystalline block cannot be sufficiently exhibited according to the content of the block polyester. On the other hand, when the content of the crystalline block is higher than the upper limit, there is the possibility that the compatibility of block polyester and the amorphous polyester described later lowers, since the content of the amorphous block relatively lowers.

Crystalline block may contain components other than the above alcohol components and carboxylic acid components.

The average molecular weight (weight average molecular weight, Mw) of the block polyester containing the crystalline block is not particularly limited, but it is preferably from  $1 \times 10^4$  to  $3 \times 10^5$ , and more preferably from  $1.2 \times 10^4$  to  $1.5 \times 10^5$ . When the average molecular weight, Mw, is less than the lower limit, there is the possibility that the mechanical strength of the finally-obtained toner lowers and sufficient durability (storage stability) cannot

be obtained. When the average molecular weight  $M_w$  is too small, cohesive failure is liable to occur in the fixing of the toner, and the offset resistance tends to lessen.

While when the average molecular weight  $M_w$  exceeds the upper limit, intercrystalline crack is liable to occur in the fixing of the toner, and the wettability to a transfer material (a recording medium), e.g., paper, lowers, as a result the quantity of heat required in fixing increases.

The glass transition temperature  $T_g$  of block polyester is not particularly restricted, but it is preferably from 50 to 75°C, and more preferably from 55 to 70°C. When the glass transition temperature is less than the lower limit, the storage stability (heat resistance) of the toner decreases, and there are cases where fusing occurs among toner particles according to the use environment. On the other hand, when the glass transition temperature exceeds the upper limit, low temperature fixing ability and transparency decrease. When the glass transition temperature is too high, there is the possibility that the effect of the thermal treatment of sphere-making as described later cannot be sufficiently exhibited. Glass transition temperature can be measured in accordance with JIS K 7121.

The softening temperature of block polyester  $T_h$  is not particularly restricted, but it is preferably from 90

to 160°C, and more preferably from 100 to 150°C. When the softening temperature is less than the lower limit, the storage stability of the toner lowers and there is the possibility that sufficient durability cannot be obtained.

- 5 When the softening temperature is too low, cohesive failure is liable to occur in the fixing of the toner, and the offset resistance tends to lessen. While when the softening temperature exceeds the upper limit, intercrystalline crack is liable to occur in the fixing of the toner, and the wettability to a transfer material (a recording medium), e.g., paper, lowers, as a result the quantity of heat required in fixing increases. The softening temperature  $T_h$  can be found as the temperature of the point on the flow curve corresponding to  $h/2$  of the flow chart for analysis which can be obtained by measuring by using a flow tester on conditions of a sample amount of 1 g, pit of the die of 1 mm, length of the die of 1 mm, load of 20 kgf, preheating time of 300 seconds, temperature at starting of measurement of 50°C, and velocity of temperature-up of 5°C/min.

The melting temperature  $T_m$  of block polyester (the central value  $T_{mp}$  of the peaks in the measurement of the endothermic peak of melting temperature by differential scanning calorimetry as described later) is not particularly restricted, but it is preferably 190°C or more,

and more preferably from 190 to 230°C. When the melting temperature is less than 190°C, there is the possibility that the effect of improving offset resistance cannot be sufficiently obtained. While when the melting temperature is too high, it is required to increase the temperature of materials in the kneading process as described later. As a result, the ester exchange reaction of resin materials is liable to progress, and there are cases where the design of resin is difficult to be sufficiently reflected in the toner finally obtained. Melting temperature can be obtained, e.g., by the measurement of endothermic peak by differential scanning calorimetry (DSC).

When the toner finally obtained is used in a fixing unit having a fixing roller as described later, it is preferred to satisfy the relationship of  $T_{fix} \leq T_m (B) \leq (T_{fix} + 100)$ , more preferably to satisfy the relationship  $(T_{fix} + 10) \leq T_m (B) \leq (T_{fix} + 70)$ , with the melting temperature of block polyester (the central value  $T_m$  of the peaks in the measurement of the endothermic peak of melting temperature by differential scanning calorimetry as described later) as  $T_m (B)$  [°C], and the standard set surface temperature of the fixing roller as  $T_{fix}$  [°C]. By satisfying the relationship, the adhesion of the toner to the fixing roller of the fixing unit described later can be effectively prevented. Further, since block polyester has

a property of making crystal of a proper size easily as described above, stability and durability can be maintained after fixation of the toner on a recording medium by satisfying the above relationship. Particularly when block polyester is used in combination with the amorphous polyester described later, the amorphous polyester can be sufficiently softened at fixing time. Accordingly, the fixing ability (fixing strength) of the toner on a recording medium can be satisfactorily elevated and the low temperature fixing ability of the toner can be excelled. In addition, since block polyester is liable to form crystals having high hardness, the obtained toner is excellent in the stability after fixation.

It is preferred that the melting temperature of block polyester be higher than the softening temperature of the later-described amorphous polyester. By this constitution, the toner finally obtained is improved in the stability of configuration and shows particularly excellent stability against mechanical stresses. Further, when the melting temperature of block polyester is higher than the softening temperature of the later-described amorphous polyester, e.g., in the thermal treatment of sphere-making as described later, the amorphous polyester can be thoroughly softened while ensuring the stability of configuration of the powders for manufacturing the toner in a certain degree

by the block polyester. As a result, the thermal sphere-making treatment can be carried out efficiently, and the degree of circularity of the toner (toner particles) finally obtained can be made relatively high.

5       Incidentally, as described above, as block polyesters contain crystalline blocks having high crystallinity, they have a so-called sharp melt property as compared with relatively low crystalline resins (e.g., the later-described amorphous polyesters and the like).

10       As the index showing crystallinity, e.g., with the central value of the peak as  $T_{mp}$  [°C] and the shoulder peak value as  $T_{ms}$  [°C] in the measurement of endothermic peak of melting temperature by differential scanning calorimetry (DSC), the  $\Delta T$  value represented by  $\Delta T = T_{mp} - T_{ms}$  is  
15       exemplified. The smaller the  $\Delta T$  value, the higher is the crystallinity.

      The  $\Delta T$  value of block polyester is preferably 50°C or less, and more preferably 20°C or less. The measuring conditions of  $T_{mp}$  [°C] and  $T_{ms}$  [°C] are not especially  
20       restricted, but the measurement is effected by increasing the temperature of the sample block polyester to 200°C at a temperature-up velocity of 10°C/min, lowering the temperature at a temperature-down velocity of 10°C/min, and again at a temperature-up velocity of 10°C/min.

25       Block polyesters are higher in crystallinity than the

amorphous polyesters described later. Accordingly, the relationship  $\Delta T_A > \Delta T_B$  is satisfied, when the  $\Delta T$  value of amorphous polyester as  $\Delta T_A$  [ $^{\circ}\text{C}$ ] and the  $\Delta T$  value of block polyester as  $\Delta T_B$  [ $^{\circ}\text{C}$ ]. In particular in the present invention, it is preferred the relationship  $\Delta T_A - \Delta T_B > 10$  be satisfied, and it is more preferred that the relationship  $\Delta T_A - \Delta T_B > 30$  be satisfied. By satisfying the relationship, the above-described effects become further conspicuous. However, when the crystallinity of amorphous polyester is particularly low, there is the case where at least either  $T_{mp}$  or  $T_{ms}$  is difficult to measure (discrimination is difficult). In such a case,  $\Delta T_A$  is taken as  $\infty$  [ $^{\circ}\text{C}$ ].

The heat of fusion  $E_f$  of block polyester obtained in the measurement of endothermic peak of melting temperature by differential scanning calorimetry is preferably 5 mJ/mg or more, and more preferably 15 mJ/mg or more. When the heat of fusion  $E_f$  is less than 5 mJ/mg, there is the possibility that the above effects due to having crystalline block cannot be sufficiently exhibited. However, the heat of fusion does not include the quantity of heat of endothermic peak of glass transition temperature. The measuring conditions of the endothermic peak of the heat of fusion are not especially restricted. The heat of fusion can be found as the value measured by, e.g.,

increasing the temperature of the sample block polyester to 200°C at a temperature-up velocity of 10°C/min, lowering the temperature at a temperature-down velocity of 10°C/min, and again at a temperature-up velocity of 10°C/min.

5       Block polyesters are preferably linear type polymers (polymers not having a crosslinked structure). Linear type polymers have a small friction coefficient as compared with crosslinked polymers. Due to a small friction coefficient, excellent lubricating property can be obtained and the  
10       transfer efficiency of the toner obtained is further improved.

Block polyesters may have blocks other than the aforementioned crystalline blocks and amorphous blocks.

15   1-2. Amorphous polyester:

Amorphous polyesters are lower in crystallinity than the crystalline blocks as described above.

Amorphous polyester is a component that mainly contributes to the improvement of the dispersibility (e.g.,  
20       dispersibility of colorants, release agents, electrification inhibitors and the like), the pulverizing property of kneaded products in manufacturing a toner, fixing ability of a toner (in particular, low temperature fixing ability), transparency, mechanical characteristics  
25       (e.g., elasticity, mechanical strength and the like),



electrification property, and moisture resistance of each component constituting a toner. In other words, when amorphous polyesters described later are not contained in a toner, there are cases where characteristics required of the toner as enumerated above are difficult to be sufficiently shown.

The constitutional components of amorphous polyester are described below.

As the alcohol components constituting amorphous polyesters, those having two or more hydroxyl groups can be used, preferably diols having two hydroxyl groups. As such diol components having two hydroxyl groups, aromatic diols having an aromatic cyclic structure and aliphatic diols not having an aromatic cyclic structure are exemplified. As the aromatic diols, e.g., bisphenol A and alkylene oxide adducts of bisphenol A are exemplified. As the aliphatic diols, such as chain diols, e.g., ethylene glycol, 1,3-propanediol, 1,2-propylene glycol, 1,3-propylene glycol, 1,4-butanediol, diethylene glycol, 1,5-pentanediol, 1,6-hexanediol, dipropylene glycol, triethylene glycol, tetraethylene glycol, 1,2-propanediol, 1,3-butanediol, 2,3-butanediol, neopentyl glycol (2,2-dimethylpropane-1,3-diol), 1,2-hexanediol, 2,5-hexane-diol, 2-methyl-2,4-pentanediol, 3-methyl-1,3-pentanediol, 2-ethyl-1,3-hexanediol, 2-butyl-2-ethyl-1,3-propanediol, 2,4-diethyl-1,5-pentanediol,

polyethylene glycol, polypropylene glycol, and  
polytetramethylene glycol, and cyclic diols, e.g., 2,2-  
bis(4-hydroxycyclohexyl)propane, alkylene oxide adducts of  
2,2-bis(4-hydroxycyclohexyl)-propane, 1,4-cyclohexanediol,  
5 1,4-cyclohexanedimethanol, hydrogenated bisphenol A, and  
alkylene oxide adducts of hydrogenated bisphenol A, are  
exemplified.

As the carboxylic acid components constituting  
amorphous polyester, divalent or higher carboxylic acids  
10 and derivatives thereof (e.g., acid anhydrides and lower  
alkyl esters) can be used, but divalent dicarboxylic acids  
and derivatives thereof are preferably used. The examples  
of dicarboxylic acids include, e.g., o-phthalic acid  
(phthalic acid), terephthalic acid, isophthalic acid,  
15 succinic acid, adipic acid, sebacic acid, azelaic acid,  
octylsuccinic acid, cyclohexanedicarboxylic acid, fumaric  
acid, maleic acid, itaconic acid, and derivatives of these  
acids (e.g., anhydrides and lower alkyl esters).

The dicarboxylic acid components constituting  
20 amorphous polyester are not particularly restricted, but it  
is preferred that the dicarboxylic acid components at least  
partially have a terephthalic acid skeleton, more  
preferably 80 mol% or more of the dicarboxylic acid  
components have a terephthalic acid skeleton, and still  
25 more preferably 90 mol% or more of the dicarboxylic acid

components have a terephthalic acid skeleton. By this constitution, the toner finally obtained comes to be a toner well balanced in various characteristics required of the toner.

5 It is preferred that 50 mol% or more (more preferably 80 mol% or more) of the monomer components constituting amorphous polyester be the same monomer components constituting amorphous block. That is, amorphous polyester and amorphous block are preferably composed of the same  
10 monomer components. The compatibility of block polyester and amorphous polyester becomes particularly excellent by this constitution. The term "monomer components" used here does not mean the monomers used in the manufacture of block polyester and amorphous polyester, but means monomer  
15 components contained in block polyester and amorphous polyester.

Amorphous polyester may contain components other than the above diol components and dicarboxylic acid components.

The average molecular weight (weight average  
20 molecular weight,  $M_w$ ) of amorphous polyesters is not particularly limited, but it is preferably from  $5 \times 10^3$  to  $4 \times 10^4$ , and more preferably from  $8 \times 10^3$  to  $2.5 \times 10^4$ . When the average molecular weight  $M_w$  is less than the lower limit, there is the possibility that the mechanical strength of  
25 the finally-obtained toner lowers and sufficient durability

(storage stability) cannot be obtained. When the average molecular weight  $M_w$  is too small, cohesive failure is liable to occur in the fixing of the toner, and the offset resistance tends to lessen. While when the average molecular weight  $M_w$  exceeds the upper limit, intercrystalline crack is liable to occur in the fixing of the toner, and the wettability to a transfer material (a recording medium); e.g., paper, lowers, as a result the quantity of heat required in fixing increases.

The glass transition temperature  $T_g$  of amorphous polyester is not particularly restricted, but it is preferably from 50 to 75°C, and more preferably from 55 to 70°C. When the glass transition temperature is less than the lower limit, the storage stability (heat resistance) of the toner decreases, and there are cases where fusing occurs among toner particles according to the use environment. On the other hand, when the glass transition temperature exceeds the upper limit, low temperature fixing ability and transparency decrease. When the glass transition temperature is too high, there is the possibility that the effect of the thermal treatment of sphere-making as described later cannot be sufficiently exhibited. Glass transition temperature can be measured in accordance with JIS K 7121.

The softening temperature of amorphous polyester  $T_s$

is not particularly restricted, but it is preferably from 90 to 160°C, more preferably from 100 to 150°C, and still more preferably from 100 to 130°C. When the softening temperature is less than the lower limit, the storage stability of the toner lowers and there is the possibility that sufficient durability cannot be obtained. When the softening temperature is too low, cohesive failure is liable to occur in the fixing of the toner, and the offset resistance tends to lessen. While when the softening temperature exceeds the upper limit, intercrystalline crack is liable to occur in the fixing of the toner, and the wettability to a transfer material (a recording medium), e.g., paper, lowers, as a result the quantity of heat required in fixing increases.

Taking the softening temperature of amorphous polyester as  $T_h$  (A) [°C], and the melting temperature of the block polyester as  $T_m$  (B), it is preferred that the relationship  $T_m$  (B) > ( $T_h$  (A) + 60) be satisfied, and it is more preferred the relationship ( $T_h$  (A) + 60) <  $T_m$  (B) < ( $T_h$  (A) + 150) be satisfied. By satisfying the relationship, the amorphous polyester can be thoroughly softened while ensuring the stability of configuration of the toner powder in a certain degree by the block polyester at relatively high temperature. As a result, the viscosity of the toner particles can be made relatively low near the fixing

temperature of the toner and the stress relaxation time of the toner can be prolonged. Further, the thermal sphere-making treatment described later can be carried out efficiently, and the degree of circularity of the toner (toner particles) finally obtained can be further improved by satisfying the above relationship. The toner can exhibit excellent fixing ability in a broad temperature range by satisfying the above relationship.

The softening temperature  $T_s$  can be found as the temperature of the point on the flow curve corresponding to  $h/2$  of the flow chart for analysis which can be obtained by measuring by using a flow tester on conditions of a sample amount of 1 g, pit of the die of 1 mm, length of the die of 1 mm, load of 20 kgf, preheating time of 300 seconds, temperature at starting of measurement of 50°C, and velocity of temperature-up of 5°C/min.

Amorphous polyesters are preferably linear type polymers (polymers not having a crosslinked structure). Linear type polymers have a small friction coefficient as compared with crosslinked polymers. Due to a small friction coefficient, excellent lubricating property can be obtained and the transfer efficiency of the toner obtained is further improved.

As has been described, when block polyesters and amorphous polyesters are used in combination, the

characteristics of block polyesters as mentioned above and the characteristics of amorphous polyesters can be compatible, by which it becomes possible for the toner finally obtained to possess resistance against mechanical stresses (to have sufficient physical stability) and show satisfactory fixing ability (fixing strength) in a broad temperature range.

The compounding ratio of block polyester and amorphous polyester is preferably from 5/95 to 45/55 by weight, and more preferably from 10/90 to 30/70. When the compounding ratio of block polyester is too low, the synergistic effect as described above cannot be sufficiently shown, and there is the possibility that the offset resistance of the toner cannot be improved sufficiently. On the other hand, when the compounding ratio of amorphous polyester is too low, the synergistic effect as described above cannot be sufficiently shown, and there is the possibility that satisfactory low temperature fixing ability and transparency cannot be obtained. Further, when the compounding ratio of amorphous polyester is too low, there is the case where efficient and uniform pulverization is difficult in the pulverization process in the manufacture of toner.

Resins (binder resins) may contain components other than the aforementioned polyester resins.

As the resin components other than polyester resins (the third resin components), e.g., homopolymers or copolymers containing styrene or a styrene substitution product, e.g., polystyrene, poly- $\alpha$ -methylstyrene, chloropolystyrene, styrene-chlorostyrene copolymers, styrene-propylene copolymers, styrene-butadiene copolymers, styrene-vinyl chloride copolymers, styrene-vinyl acetate copolymers, styrene-maleic acid copolymers, styrene-acrylic ester copolymers, styrene-methacrylic ester copolymers, styrene-acrylic ester-methacrylic ester copolymers, styrene- $\alpha$ -methyl chloroacrylate copolymers, styrene-acrylonitrile-acrylic ester copolymers, and styrene-vinylmethyl ether copolymers, epoxy resins, urethane-modified epoxy resins, silicone-modified epoxy resins, vinyl chloride resins, rosin-modified maleic acid resins, phenyl resins, polyethylene, polypropylene, ionomer resins, polyurethane resins, silicone resins, ketone resins, ethylene-ethyl acrylate copolymers, xylene resins, polyvinyl butyral resins, terpene resins, phenol resins, aliphatic or alicyclic hydrocarbon resins are exemplified. These resins can be used either individually or as a combination of two or more thereof.

The content of these resins in the materials is not especially restricted, but the content is preferably from 50 to 98 wt.%, and more preferably from 85 to 97 wt.%.



When the content of resins is less than the lower limit, there is the possibility that the functions of resins (e.g., good fixing ability in a broad temperature range) cannot be sufficiently shown. On the other hand, when the content of resins exceeds the upper limit, the contents of the components other than resins, e.g., colorants, relatively lower, and it becomes difficult to sufficiently show the characteristics of toners, e.g., coloring.

As the colorants, pigments and dyes etc. can be used.

- 10 The examples of pigments and dyes include, e.g., carbon black, spirit black, lamp black (C.I. No. 77266), magnetite, titanium black, chrome yellow, zinc chrome, cadmium yellow, mineral fast yellow, navel yellow, Naphthol Yellow S, Hansa Yellow G, Permanent Yellow NCG, chrome yellow, benzidine
- 15 yellow, quinoline yellow, Tartrazine Lake, chrome orange, molybdenum orange, Permanent Orange GTR, Pyrazolone Orange, Benzidine Orange G, cadmium red, Permanent Red 4R, Watchung Red Calcium Salt, eosine lake, Brilliant Carmine 3B, manganese violet, Fast Violet B, Methyl Violet Lake,
- 20 Prussian blue, cobalt blue, Alkali Blue Lake, Victoria Blue Lake, Fast Sky Blue, Indanthrene Blue BC, ultramarine, aniline blue, Phthalocyanine Blue, chalco-oil blue, chrome green, chromium oxide, Pigment Green B, Malachite Green Lake, Phthalocyanine Green, Final Yellow Green G, Rhodamine
- 25 6G, quinacridone, Rose Bengale (C.I. 45432), C.I. Direct

Red, C.I. Direct Red 4, C.I. Acid Red, C.I. Basic Red, C.I. Mordant Red 30, C.I. Pigment Red 48:1, C.I. Pigment Red 57:1, C.I. Pigment Red 122, C.I. Pigment Red 184, C.I. Direct Blue 1, C.I. Direct Blue 2, C.I. Acid Blue 9, C.I. 5 Acid Blue 15, C.I. Basic Blue 3, C.I. Basic Blue 5, C.I. Mordant Blue 7, C.I. Pigment Blue 15:1, C.I. Pigment Blue 15:3, C.I. Pigment Blue 5:1, C.I. Direct Green 6, C.I. Basic Green 4, C.I. Basic Green 6, C.I. Pigment Yellow 17, C.I. Pigment Yellow 93, C.I. Pigment Yellow 97, C.I. 10 Pigment Yellow 12, C.I. Pigment Yellow 180, C.I. Pigment Yellow 162, Nigrosine Dye (C.I. No. 50415B), metal complex dyes, metal oxides, e.g., silica, aluminum oxide, magnetite, maghemite, various ferrites, cupric oxide, nickel oxide, zinc oxide, zirconium oxide, titanium oxide, and magnesium 15 oxide, and magnetic materials containing magnetic metals, e.g., Fe, Co or Ni. These pigments and dyes can be used alone or in combination of two or more.

Since the binder resins in the present invention are great in intermolecular bonding strength and highly 20 crystalline polymers, the lowering breadth of  $T_g$  can be lessened when the molecule is designed to lower  $T_m$  by lowering the molecular weight, therefore, low  $T_m$  and low  $T_g$  can be compatible. Further, the melt viscosity at running point of 50% can be made from  $2 \times 10^2$  to  $3 \times 10^4$  Pa·s, thus, the 25 toner of the invention is preferred for oil-less fixing.

The weight average molecular weight ( $M_w$ ) of the binder resins of the first to second invention is from 5,000 to 100,000, preferably from 6,000 to 70,000. When the weight average molecular weight ( $M_w$ ) is smaller than 5,000, there arises a problem in hot offset resistance, since the internal cohesive strength of the toner becomes too weak. While when the weight average molecular weight is greater than 100,000, the production and pulverization are deteriorated.

10 The toner of the first to second invention has a softening temperature ( $T_m$ ) of from 90 to 150°C, preferably from 100 to 140°C, and more preferably from 100 to 130°C. When the softening temperature ( $T_m$ ) is lower than 90°C, there arises a problem in hot offset resistance, while when  
15 it is higher than 150°C, fixing strength lowers.

The toner of the first to second invention has a glass transition temperature ( $T_g$ ) of from 50 to 75°C, preferably from 55 to 70°C. When the glass transition temperature ( $T_g$ ) is lower than 55°C, heat storage stability  
20 lowers, and when it is higher than 75°C, there arises a problem in productivity, e.g., pulverization.

The toner of the present invention may contain a charge controlling agent (CCA), and if necessary, a release  
25 agent, a dispersant, and magnetic particles. These

compounds may be dispersed in the starting material polyols, alternatively they may be arbitrarily blended by kneading after forming the resin.

Charge controlling agents (CCA) are not particularly  
5 restricted, and various kinds of organic and inorganic compounds can be used so long as they can give positive or negative charge by frictional electrification.

As the examples of positive charge controlling agents,  
e.g., Nigrosine Base EX (manufactured by Orient Chemical  
10 Industry Co., Ltd.), quaternary ammonium salt P-51  
(manufactured by Orient Chemical Industry Co., Ltd.),  
Nigrosine Bontoron N-01 (manufactured by Orient Chemical  
Industry Co., Ltd.), Sudan Chief Schwartz BB (Solvent Black  
3: Color Index 26150), Fetschwartz HBN (C.I. No. 26150),  
15 Brilliant Spirits Schwartz TN (manufactured by Farben  
Fabriken Bayer A.G.), and Zapon Schwartz X (manufactured by  
Farberke Hoechst A.G.), in addition, alkoxylated amine,  
alkylamide, and molybdic acid chelate pigments are  
exemplified. Of these compounds, quaternary ammonium salt  
20 P-51 is preferably used.

As the examples of negative charge controlling agents,  
e.g., Oil Black (Color Index 26150), Oil Black BY  
(manufactured by Orient Chemical Industry Co., Ltd.),  
Bontoron S-22 (manufactured by Orient Chemical Industry Co.,  
25 Ltd.), salicylic acid metal complex E-81 (manufactured by

Orient Chemical Industry Co., Ltd.), thioindigo series pigments, sulfonamide derivatives of copper phthalocyanine, Spiron Black TRH (manufactured by HODOGAYA CHEMICAL Co., Ltd.), Bontron S-34 (manufactured by Orient Chemical Industry Co., Ltd.), Nigrosine SO (manufactured by Orient Chemical Industry Co., Ltd.), Celesschwartz (R) G (manufactured by Farben Fabriken Bayer A.G.), Chromogenschwartz ETOO (C.I. No. 14645), and Azo Oil Black (R) (manufactured by National Aniline Co.) are exemplified.

10 Of these compounds, salicylic acid metal complex E-81 is preferably used.

These charge controlling agents can be used either individually or as a combination of two or more thereof, and the addition amount of charge controlling agents added

15 to a binder resin is from 0.001 to 5 parts by weight per 100 parts by weight of the binder resin, preferably 0.001 to 3 parts by weight.

The binder resin which is used in the toner of the present invention is excellent in heat melt characteristics

20 according to the molecular weight range, and a release agent is not necessary according to the viscoelastic characteristics in the fixing temperature range, but when a release agent is used, the amount is 4 parts by weight (4 wt.%) or less per 100 parts by weight of the binder resin,

25 and preferably from 0 to 3 parts by weight.

The specific examples of release agents include paraffin waxes, polyolefin waxes, modified waxes having an aromatic group, hydrocarbon compounds having an alicyclic group, natural waxes, long chain carboxylic acids having a long chain hydrocarbon chain having 12 or more carbon atoms [ $\text{CH}_3(\text{CH}_2)_{11}$  or  $\text{CH}_3(\text{CH}_2)_{12}$  or higher aliphatic carbon chain], the esters thereof, metal salts of fatty acid, fatty acid amide and fatty acid bisamide. Compounds having different softening temperatures may be used as mixture. The specific examples of paraffin waxes include paraffin waxes (manufactured by NIPPON OIL COMPANY LIMITED), paraffin waxes (manufactured by Nippon Seiro Co., Ltd.), micro-wax waxes (manufactured by NIPPON OIL COMPANY LIMITED), micro-crystalline waxes (manufactured by Nippon Seiro Co., Ltd.), hard paraffin waxes (manufactured by Nippon Seiro Co., Ltd.), PE-130 (manufactured by Hoechst A.G.), Mitsui Hi-Wax 110P (manufactured by Mitsui Petrochemical Industries, Ltd.), Mitsui Hi-Wax 220P (manufactured by Mitsui Petrochemical Industries, Ltd.), Mitsui Hi-Wax 660P (manufactured by Mitsui Petrochemical Industries, Ltd.), Mitsui Hi-Wax 210P (manufactured by Mitsui Petrochemical Industries, Ltd.), Mitsui Hi-Wax 320P Mitsui Hi-Wax 410P (manufactured by Mitsui Petrochemical Industries, Ltd.), Mitsui Hi-Wax 420P (manufactured by Mitsui Petrochemical Industries, Ltd.), modified wax JC-1141 (manufactured by

Mitsui Petrochemical Industries, Ltd.), modified wax JC-2130 (manufactured by Mitsui Petrochemical Industries, Ltd.), modified wax JC-4020 (manufactured by Mitsui Petrochemical Industries, Ltd.), modified wax JC-1142 (manufactured by Mitsui Petrochemical Industries, Ltd.), modified wax JC-5020 (manufactured by Mitsui Petrochemical Industries, Ltd.), beeswax, carnauba wax and montan wax. As fatty acid metal salts, zinc stearate, calcium stearate, magnesium stearate, zinc oleate, zinc palmitate, and magnesium palmitate are exemplified.

As polyolefin waxes, e.g., low molecular weight polypropylene, low molecular weight polyethylene, oxidation type polypropylene and oxidation type polyethylene are exemplified. The specific examples of polyolefin-based waxes include non-oxidation type polyethylene waxes, e.g., Hoechst Wax PE520, Hoechst Wax PE130, Hoechst Wax PE190 (manufactured by Hoechst A.G.), Mitsui Hi-Wax 200, Mitsui Hi-Wax 210, Mitsui Hi-Wax 210M, Mitsui Hi-Wax 220, Mitsui Hi-Wax 220M (manufactured by Mitsui Petrochemical Industries, Ltd.), and SANWAX 131-P, SANWAX 151-P, SANWAX 161-P (manufactured by Sanyo Chemical Industries Co., Ltd.), oxidation type polyethylene waxes, e.g. Hoechst Wax PED121, Hoechst Wax PED153, Hoechst Wax PED521, Hoechst Wax PED522, Hoechst Wax Ceridust 3620, Hoechst Wax Ceridust VP130, Hoechst Wax Ceridust VP5905, Hoechst Wax Ceridust VP9615A,

Hoechst Wax Ceridust TM9610F, Hoechst Wax Ceridust 3715  
(manufactured by Hoechst A.G.), Mitsui Hi-Wax 420M  
(manufactured by Mitsui Petrochemical Industries, Ltd.),  
and SANWAX E-300, SANWAX E-250P (manufactured by Sanyo  
5 Chemical Industries Co., Ltd.), non-oxidation type  
polypropylene waxes, e.g., Hoechst Wachs PP230  
(manufactured by Hoechst A.G.), VISCOL 330-P, VISCOL 550-P,  
VISCOL 660-P, (manufactured by Sanyo Chemical Industries  
Co., Ltd.), and oxidation type polypropylene waxes, e.g.,  
10 VISCOL TS-200 (manufactured by Sanyo Chemical Industries  
Co., Ltd.). These release agents can be used alone or in  
combination of two or more. As the release agent added  
according to necessity, it is preferred to use a compound  
having a softening temperature (a melting temperature) of  
15 from 40 to 130°C, preferably from 50 to 120°C. A softening  
temperature is an endothermic main peak value on the DSC  
endothermic curve measured with "DSC120" (a product of  
Seiko Instruments Inc.).

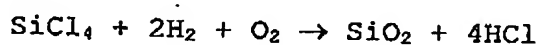
The mother particles of the toner of the present  
20 invention can be obtained by kneading the above  
compositions, melting, then pulverizing the obtained  
product by finely grinding member and classifying. A  
flowability improver may be externally added to the  
compositions for improving the flowability.

25 Organic and inorganic fine particles can be used as



the flowability improver. For instance, fluorine resin powders, e.g., vinylidene fluoride fine powders, polytetrafluoroethylene fine powders, acrylate resin fine powders; fatty acid metal salts, e.g., zinc stearate, calcium stearate, lead stearate; metal oxides, e.g., iron oxide, aluminum oxide, titanium oxide, zinc oxide; and surface-treated silica obtained by treating silica fine powders manufactured by a wet or dry manufacturing process with a silane coupling agent, a titanium coupling agent or a silicone oil, are exemplified as flowability improvers. These compounds are used either individually or as a combination of two or more thereof.

Preferred flowability improvers are fine powders manufactured by a vapor phase oxidation method of a silicon halogen compound, i.e., so-called dry process silica or fumed silica, which can be manufactured by well-known methods, for example, a method which utilizes heat decomposition oxidation reaction in oxyhydrogen flame of silicon tetrachloride gas, and fundamental reaction formula is as follows.



Further, in this manufacturing process, it is also possible to obtain complex fine powders of silica with other metal oxides by using other metal halogen compounds, e.g., aluminum chloride or titanium chloride, together with

a silicon halogen compound, and these complex fine powders are also included in the scope of the invention. It is preferred for these silica fine powders to have an average primary particle size of from 0.001 to 2  $\mu\text{m}$ , particularly preferably from 0.002 to 0.2  $\mu\text{m}$ . As commercially available silica fine powders manufactured by a vapor phase oxidation method of a silicon halogen compound that are used in the present invention, the following commercial products are exemplified. For instance, AEROSIL 130, AEROSIL 200, AEROSIL 300, AEROSIL 380, TT600, MOX170, MOX80, and COK84 (manufactured by Nippon Aerosil Co., Ltd.), Ca-O-SiL M-5, MS-7, MS-75, HS-5 and EH-5 (manufactured by CABOT Co.), Wacker HDK N20 V15, N20E, T30 and T40 (manufactured by WACKER-CHEMIE GMBH), D-C Fine Silica (manufactured by Dow Corning Co.), and Fransol (manufactured by Fransil Co.) are exemplified.

It is more preferred to use the silica fine powders manufactured by a vapor phase oxidation method of a silicon halogen compound subjected to hydrophobitization treatment. Of the hydrophobitization-treated silica fine powders, those treated so as to have a hydrophobitization degree measured by a methanol titration test of from 30 to 80 are particularly preferred. The hydrophobitization treatment is performed by chemically treating the silica fine powders with organic silicon compounds that react with the silica

fine powders or physically adsorbed onto the silica fine powders. A preferred method is treating the silica fine powders manufactured by a vapor phase oxidation method of a silicon halogen compound with an organic silicon compound.

- 5       The examples of such organic silicon compounds include hexamethyldisilazane, trimethylsilane, trimethylchlorosilane, trimethylethoxysilane, dimethyldichlorosilane, methyltrichlorosilane, allyldimethylchlorosilane, allylphenyldichlorosilane, benzyldimethylchlorosilane, bromomethyldimethylchlorosilane,  $\alpha$ -chloroethyltrichlorosilane,  $\beta$ -chloroethyltrichlorosilane, chloromethyldimethylchlorosilane, triorganosilylmercaptan, trimethylsilylmercaptan, triorganosilyl acrylate, vinyl dimethylacetoxysilane, dimethylethoxysilane, 15 dimethyldimethoxysilane, diphenyldiethoxysilane, hexamethyldisiloxane, 1,3-divinyldimethyltetramethyldisiloxane, 1,3-diphenyldimethyltetramethyldisiloxane, and dimethylpolysiloxane having from 2 to 12 siloxane units per a molecule, wherein every unit at terminal has a hydroxyl group bonded to Si.
- 20   These compounds are used either individually or a combination of two or more thereof.

Silica fine powders subjected to hydrophobitization treatment have a particle size of from 0.003 to 0.1  $\mu\text{m}$ , preferably from 0.005 to 0.05  $\mu\text{m}$ . As commercially 25 available products, there are Taranocks 500 (manufactured

by Tarco Co.) and AEROSIL R-972 (manufactured by Nippon Aerosil Co., Ltd.).

The addition amount of flowability improvers is from 0.01 to 5 parts by weight per 100 parts by weight of the binder resin, preferably from 0.1 to 3 parts by weight. When the addition amount is less than 0.01 parts by weight, flowability is not improved, and when it is more than 5 parts by weight, fog or blotting occurs or the scattering of the toner in the machine is accelerated.

10

The image-forming apparatus according to the present invention for forming an image with the toner of the present invention is described below.

As is not shown in a drawing, similarly to conventional image-forming apparatus, the image-forming apparatus of the invention comprises at least an image carrier on which an electrostatic latent image is formed, a developing unit which develops the electrostatic latent image on the image carrier to form a toner image by a toner, a transferring unit which transfers the toner image on the image carrier to a recording medium, e.g., paper, and a fixing unit which fixes the toner image transferred to the recording medium by heating. In that case, since the image carrier, the developing unit and the transfer unit are the same as those conventionally used description of each unit

is omitted.

The fixing unit is equipped with oil-less two rollers. However, the present invention is not limited thereto.

Fig. 1 is a drawing typically showing an example of a fixing unit of the present invention. In Fig. 1, 1 is a fixing roller (a heating roller), 2 is a backup roller (a pressing roller), 3 is a releasing pawl, and 4 is a recording medium, e.g., paper.

Fixing roller 1 may be either a monolayer type or a multilayer type. A monolayer type roller comprises a core bar having a diameter of from 15 to 50 mm and a built-in heating member, and a silicone rubber layer or a fluorine rubber layer having a thickness of from 0.1 to 20 mm, preferably from 0.5 to 3 mm, laminated around the core bar. A multilayer type roller comprises a core bar having a diameter of from 15 to 50 mm and a built-in heating member, an elastic layer having a thickness of from 0.1 to 20 mm, preferably from 0.5 to 3 mm, and a coat layer having a thickness of from 0.05 to 2 mm, preferably from 0.1 to 1 mm, laminated around the core bar in sequence. As the combination of the elastic layer and the coat layer, the following combinations are exemplified.

(1) An elastic layer comprising a silicone resin, and a coat layer comprising a fluorine resin;

(2) An elastic layer comprising a silicone rubber, and a

coat layer comprising a fluorine rubber; and

(3) An elastic layer comprising a silicone rubber, and a coat layer comprising a silicone rubber and a fluorine rubber.

5       The rubber layer in a monolayer and the elastic layer in multilayers are layers having rubber hardness of 30° or less, preferably 15° or less, in JIS A hardness.

Backup roller 2 may be either a monolayer type or a multilayer type. A monolayer type roller comprises a core  
10 bar having a diameter of from 15 to 50 mm, and a silicone rubber layer or a fluorine rubber layer having a thickness of from 0.1 to 20 mm, preferably from 0.5 to 3 mm, laminated around the core bar. A multilayer type roller comprises a core bar having a diameter of from 15 to 50 mm,  
15 an elastic layer having a thickness of from 0.1 to 20 mm, preferably from 0.5 to 3 mm, and a coat layer having a thickness of from 0.05 to 2 mm, preferably from 0.1 to 1 mm, laminated in sequence around the core bar. As the combination of the elastic layer and the coat layer, the  
20 following combinations are exemplified.

(1) An elastic layer comprising a silicone sponge, and a coat layer comprising high releasable silicone laminated in sequence;

(2) An elastic layer comprising silicone rubber, and a  
25 coat layer comprising fluorine rubber laminated in

sequence;

- (3) An elastic layer comprising silicone rubber, and a coat layer comprising fluorine rubber latex and fluorine resin laminated in sequence; and
- 5 (4) An elastic layer comprising silicone sponge rubber, and a coat layer comprising fluorine resin (PFA tube) laminated in sequence.

The rubber layer in a monolayer and the elastic layer -- in multilayers are layers having rubber hardness of 30° or less, preferably 15° or less, in JIS A hardness.

10

The pressure (linear pressure) of fixing roller 1 and backup roller 2 is from 0.2 to 2 kgf/cm, preferably from 0.3 to 1 kgf/cm, the nip breadth is from 1 to 20 mm, preferably from 4 to 10 mm. The velocity of the rollers

15 may be set arbitrarily so that the time of transiting nip becomes from 10 to 150 msec, preferably from 30 to 100 msec.

As described above, the toner of the present invention is fixed on recording medium 4 without causing offset by the increase of elasticity and viscosity,

20 although the toner is in the state of being in contact with fixing roller (heating roller) 1. Since the toner of the invention is excellent in offset resistance at low temperature and high temperature, the fixing unit of the image-forming apparatus in the present invention can be

25 made an oil-less fixing unit not necessitating coating of a

release agent, e.g., silicone oil, on the surface of the fixing roller.

According to the image-forming apparatus in the present invention, a high quality toner image having good transparency can be formed while maintaining oil-less and good low temperature fixing ability and preventing hot offset by organically combining a toner improved in low temperature fixing ability, hot offset resistance, and transparency as described above, with an oil-less two-roller fixing unit.

Well-known methods can be applied to the measurement of the physical properties of the toner of the present invention, e.g., softening temperature ( $T_m$ ), glass transition temperature ( $T_g$ ), molecular weight, particle size, storage modulus  $G'$  and loss modulus  $G''$ , the evaluation of good offset region of the toner at fixing time, and the evaluation of transparency, and an example of these methods is described in Experimental Examples later.

## 20 Experimental Examples of the Invention

The toners of the present invention are specifically described with reference to Experimental Examples.

In the first place, the measuring methods of physical properties, dynamic viscoelasticity, the evaluation of the good region of offset at fixing time, and the evaluation of



transparency (HAZE value) of the toners in Experimental Examples of the invention are described.

(1) Measurement of softening temperature

5 (T<sub>m</sub>, melting temperature) (°C)

The softening temperature of a toner (T<sub>m</sub>) is measured by the following instrument and conditions.

(a) Measuring instrument

Constant load extrusion capillary rheometer, Flow  
10 Tester CFD-500D manufactured by Shimadzu Corporation

(b) Preparation of a measuring sample

As the measuring sample, about 1 g of a toner is compression-molded to make a cylindrical sample fitting in with the inside diameter of the cylinder of Flow Tester.

15 (c) Measuring condition

Load: 20 kgf, pit of the die: 1 mm, length of the die: 1 mm

(d) Computing method of T<sub>m</sub>

A 1/2 method

20

(2) Measuring method of glass transition temperature

(T<sub>g</sub>) (°C)

The glass transition temperature of a toner is measured by the following instrument and condition.

25 (a) Measuring instrument

Differential scanning calorimeter DSC220C/EXTRA 6000  
PC station manufactured by Seiko Instruments Inc.

(b) Preparation of a measuring sample

As the measuring sample, 10 mg of the toner is sealed  
5 in an aluminum sample container.

(c) Measuring temperature

From 20°C (starting temperature of measurement) to  
200°C (finishing temperature of measurement)

(d) Velocity of temperature up

10 10°C/min

(e)  $T_g$

The temperature at the position where endothermic  
reaction corresponding to glass transition temperature  
occurs (the shoulder position of the endothermic curve) is  
15 taken as  $T_g$ .

(3) Measurement of molecular weight distribution

A sample for GPC is prepared by dissolving 5 mg of a  
binder resin in 5 g of THF, and filtering THF-insoluble  
20 substance and contaminated products through a membrane  
filter having a pore diameter of 0.2  $\mu\text{m}$ . The thus-prepared  
sample (THF-soluble contents) is measured by GPC by the  
following conditions.

(a) Column

25 Shodex (GPC) KF806M+KF802.5, manufactured by Showa

Denko Co., Ltd.

(b) Temperature of column

30°C

(c) Solvent

5 THF (tetrahydrofuran)

(d) Flowing velocity

1.0 ml/min

(e) Detector

RI detector

10 (f) Standard sample

Monodispersed polystyrene standard sample (weight  
average molecular weight: from 580 to 3,900,000)

(4) Measurement of particle size

15 A particle size in the present invention means an  
"average particle".

A particle size is obtained by measuring relative  
weight distribution by particle size with Coulter  
Multisizer III type (manufactured by Coulter, Inc) by a 100  
20 µm aperture tube. Further, the particle sizes of external  
additives, e.g., silica particles, are measured by an  
electron microscope.

(5) Measurement of dynamic viscoelasticity by step strain

25 The dynamic viscoelasticity of the toner of the

present invention is obtained by measuring dynamic viscoelasticity with the following viscoelasticity measuring instrument by step strain by the following conditions.

5 (a) Viscoelasticity measuring instrument

Viscoelasticity measuring instrument is ARES viscoelasticity measuring system (ARES viscoelasticity measuring instrument, manufactured by Rheometric Scientific FE Co.).

10 (b) Jigs used

Two parallel plates of top and bottom (diameter:  $\phi 25$  mm) are used.

(c) Preparation of measuring sample

About 1 g of a toner is put on the bottom plate of the parallel plates, the toner is heated with a heater to the starting temperature of measurement, and the top plate of the parallel plates is put on the toner to press the toner when the toner becomes a little soft. The toner protruding from the parallel plates is removed by trimming, and the toner is fitted in with the peripheral shape of the parallel plates (i.e., the diameter of the parallel plates), and the height of the sample is adjusted to 1.0 to 2.0 mm (the gap between the top and bottom plates), to thereby prepare a cylindrical sample.

25 (d) Measuring frequency

The measuring frequency is set at 1 rad/sec (1 Hz = 6.28 rad/sec).

(e) Measuring temperature

The measuring temperature is 180°C constantly in the present invention.

(f) Measuring strain

Only the bottom plate of the parallel plates is rotated to give strain without rotating the top plate. At this time, the temperature is maintained constant and gradually greater strain is given to the measuring sample (strain of from 0.1 to 200%) by strain-dependency mode (strain sweep). And the maximum strain of the storage modulus  $G'$  of dynamic viscoelasticity in a linear region and the minimum strain in a nonlinear region (the value of nonlinear monitor is 0.06 or more) to the given strain are found. These maximum strain and minimum strain were taken as the measuring strains at measuring time of step strain.

In the next place,  $G'$  (L1) is measured by applying the thus-obtained maximum strain in a linear region in initial 5 minutes from the start of measurement,  $G'$  (NL) is measured by applying the similarly obtained strain in a nonlinear region in next 5 minutes, and  $G'$  (L2) is measured by applying the initial maximum strain in a linear region in next 5 minutes. And  $G'$  (NL) is taken as the value after 600 sec from the start of measurement,  $G'$  (L1) is taken as

the value after 300 sec from the start of measurement, G' (L2) is taken as the value after 900 sec from the start of measurement.

5    (6) Measuring method of fixing ability

      (a) Preparation of image for evaluating fixing ability

      A so-called solid image was formed with a color laser printer LP-3000C (manufactured by Seiko Epson Corporation); from which a fixing part was taken away, and J paper (manufactured by FUJI XEROX OFFICE SUPPLY) as paper for evaluation. In the present invention, the toner was uniformly adhered on the J paper to thereby form a so-called solid image, and the image-forming conditions were adjusted so that the adhered amount of the toner on the solid image was 0.4 mg/cm<sup>2</sup>. Subsequently, a 30% half tone image by isolated dot of 600 dpi of definition was formed in the 20 mm square region at the position 10 mm from the end of the paper and this half tone image was used as the image for evaluating fixing ability.

20

      (b) Fixation of image for evaluating fixing ability

      A fixing unit was detached from color laser printer KL-2010 manufactured by KONICA MINOLTA HOLDINGS, INC. and this fixing unit was used for the fixation of the image for evaluating fixing ability. The fixing unit is a heating

roller fixing unit comprising a heating roller and a pressing roller. The fixing unit was modified to be capable of being driven independently by external driving gear, and also to be capable of adjusting the fixing nip-transiting time, and further, to be capable of controlling the surface temperature of the heating roller (fixing roller) on the side which was contiguous to the image for evaluating fixing ability on J paper from 100°C to 200°C. Further, the coating member of coating silicone oil on the surface of the fixing roller was detached (the state of not mounting an oil pad) and 1,000 sheets of A4 size blank paper not printed were passed, and the surface of the fixing roller was cleaned with isopropyl alcohol to remove silicone oil from the fixing roller. The surface of the fixing roller was cleaned with isopropyl alcohol every time when the image for evaluating fixing ability transited the fixing unit hereafter, wiped with dry cotton cloth, thereby the surface of the fixing roller was maintained in a silicone oil-free state.

Thus, fixing was performed by passing the image for evaluating fixing ability on J paper through the fixing unit having the fixing roller from the surface of which silicone oil was removed at fixing nip-transiting time of 50 mm/sec so that the surface on which unfixed toner was adhered (the image for evaluating fixing ability) was the

heating roller side.

(c) Measurement of transparency (HAZE value)

Image-forming conditions were adjusted so that the  
5 adhesion amount of the toner on a solid image became 0.7  
mg/cm<sup>2</sup>, and a solid image of 20 mm square was formed at 10  
mm from the end of OHP sheet by uniformly adhering the  
toner. After fixing the solid image at 180°C, the HAZE  
value of the image was measured with a HAZE meter (HAZE  
10 METER MODEL 1001DP, manufactured by Nippon Denshoku  
Industries Co., Ltd.). The smaller the value, the higher  
is the transparency.

(d) Judgment of non-offset region

15 An unfixed image for evaluating fixing ability was  
passed through the fixing unit with stepwise varying the  
surface temperature of the fixing roller, and whether a  
part of the image that had moved to the fixing roller  
transferred to the J paper again or not when paper  
20 transited was visually judged. Non-offset region was  
judged by the criteria that the region wherein a part of  
the image moved to the J paper was taken as the offset  
region and the region wherein the image did not move was  
taken as the non-offset region.

25



(e) Measurement of good region of fixing strength

The image for evaluating fixing ability after fixation was rubbed five times with an eraser (ECR-502R for ink ball-point pen, manufactured by LION OFFICE PRODUCTS CORP.) with a load of 1 kg, and the residual rate of toner was measured according to image densities. Image densities before and after rubbing were measured by "X-Rite model 404" (manufactured by X-Rite Inc.), and image density residual rate was computed by the following equation:

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$$\text{Residual rate} = (\text{density after rubbing} / \text{density before rubbing}) \times 100 (\%)$$

As the result of measurement, the temperature range in which image density residual rate was 70% or more was taken as good region of fixing strength. In the evaluation of fixing rate, minimum temperature of good fixing strength region is used as the minimum temperature of good fixing rate.

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## EXAMPLES

### First invention

25 Experimental Examples of the toners of the first

invention are described below.

The manufacture of the resins for the toners of the first invention used in Experimental Examples is described below.

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#### Resin 1A

A mixture comprising 36 molar parts of neopentyl alcohol, 36 molar parts of ethylene glycol; 48 molar parts of 1,4-cyclohexanediol, 90 molar parts of dimethyl terephthalate, and 10 molar parts of phthalic anhydride was prepared.

A two-liter four-necked flask was equipped with a reflux condenser, a distillation column, a water separator, a nitrogen gas introducing pipe, a thermometer and a stirrer according to an ordinary method, charged with 1,000 g of the above mixture and 1 g of an esterification condensation catalyst, and esterification reaction was carried out with bleeding water and methanol generated at 180°C from the distillation column. At the point when water and methanol stopped bleeding from the distillation column, the distillation column was detached from the two-liter four-necked flask and a vacuum pump was connected to the four-necked flask. The pressure in the system was lowered to 5 mmHg or less and the reaction system was stirred at a rotary speed of 150 rpm at 200°C. Free diol

generated by the condensation reaction was discharged from the system, and the thus-obtained reaction product was taken as resin 1A. Resin 1A had a softening temperature ( $T_m$ ) of 111°C, a glass transition temperature ( $T_g$ ) of 60°C, and a weight average molecular weight ( $M_w$ ) of 13,000.

#### Resin 2A

A mixture comprising 70 molar parts of resin 1A; 15 molar parts of 1,4-butanediol, and 15 molar parts of dimethyl terephthalate was prepared.

A two-liter four-necked flask was equipped with a reflux condenser, a distillation column, a water separator, a nitrogen gas introducing pipe, a thermometer and a stirrer according to an ordinary method, charged with 1,000 g of the above mixture and 1 g of an esterification condensation catalyst, and esterification reaction was carried out with bleeding water and methanol generated at 200°C from the distillation column. At the point when water and methanol stopped bleeding from the distillation column, the distillation column was detached from the two-liter four-necked flask and a vacuum pump was connected to the four-necked flask. The pressure in the system was lowered to 5 mmHg or less and the reaction system was stirred at a rotary speed of 150 rpm at 220°C. Free diol generated by the condensation reaction was discharged from

the system, and the thus-obtained reaction product was taken as resin 2A. Resin 2A had a softening temperature ( $T_m$ ) of 149°C, a glass transition temperature ( $T_g$ ) of 64°C, and a weight average molecular weight ( $M_w$ ) of 28,000.

5

#### Master batch 1A

As the colorant, 30 wt.% of pigment Toner Magenta 6B (manufactured by Clariant Japan K.K.) was added to 70 wt.% of resin 2A. The mixture was thoroughly blended by a Henschel mixer 20B (manufactured by MITSUI MINING COMPANY, LIMITED) and kneaded with a continuous system twin roll kneader (manufactured by MITSUI MINING COMPANY, LIMITED). The kneaded product was coarsely pulverized to a particle size of about 2 mm with a pulverizer (manufactured by HOSOKAWA MICRON CORPORATION), thereby master batch 1A was obtained.

#### Master batch 2A

As the colorant, 30 wt.% of pigment Toner Magenta 6B (manufactured by Clariant Japan K.K.) was added to 70 wt.% of resin 1A. The mixture was thoroughly blended by a Henschel mixer 20B (manufactured by MITSUI MINING COMPANY, LIMITED) and kneaded with a continuous system twin roll kneader (manufactured by MITSUI MINING COMPANY, LIMITED). The kneaded product was coarsely pulverized to a particle

size of about 2 mm with a pulverizer (manufactured by HOSOKAWA MICRON CORPORATION), thereby master batch 2A was obtained.

5

#### Experimental Example 1A

To 14 parts by weight of master batch 1A, 80 parts by weight of resin 1A, 12 parts by weight of resin 2A, 1.1 parts by weight of Bontron E-81 (manufactured by Orient Chemical Industry Co., Ltd.) as CCA, and 3.3 parts by weight of carnauba wax (manufactured by NIPPON WAX CORPORATION) as the release agent were added, and thoroughly blended with a Henschel mixer 20B (manufactured by MITSUI MINING COMPANY, LIMITED), melt-kneaded with a two-shaft extruder (manufactured by TOSHIBA MACHINE CO., LTD.), cooled to normal temperature (about 25°C), pulverized with a pulverizer 200AFG (manufactured by HOSOKAWA MICRON CORPORATION), and classified with a classifier 100ATP (manufactured by HOSOKAWA MICRON CORPORATION), thereby mother particles having weight D50 of 8  $\mu$ m were obtained. To 100 parts by weight of the mother particles, 1 part by weight of silica RX200 (manufactured by Nippon Aerosil Co., Ltd.) was added and blended with a Henschel mixer 20B (manufactured by MITSUI MINING COMPANY, LIMITED), thereby a toner in Experimental Example 1A was obtained.

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### Experimental Example 2A

To 14 parts by weight of master batch 1A, 50 parts by weight of resin 1A, 42 parts by weight of resin 2A, 1.1 parts by weight of Bontron E-81 (manufactured by Orient Chemical Industry Co., Ltd.) as CCA, and 3.3 parts by weight of carnauba wax (manufactured by NIPPON WAX CORPORATION) as the release agent were added, and thoroughly blended with a Henschel mixer 20B (manufactured by MITSUI MINING COMPANY, LIMITED), melt-kneaded with a two-shaft extruder (manufactured by TOSHIBA MACHINE CO., LTD.), cooled to normal temperature (about 25°C), pulverized with a pulverizer 200AFG (manufactured by HOSOKAWA MICRON CORPORATION), and classified with a classifier 100ATP (manufactured by HOSOKAWA MICRON CORPORATION), thereby mother particles having weight D50 of 8  $\mu$ m were obtained. To 100 parts by weight of the mother particles, 1 part by weight of silica RX200 (manufactured by Nippon Aerosil Co., Ltd.) was added and blended with a Henschel mixer 20B (manufactured by MITSUI MINING COMPANY, LIMITED), thereby a toner in Experimental Example 2A was obtained.

### Experimental Example 3A

To 14 parts by weight of the above master batch 1A,

70 parts by weight of resin 1A, 22 parts by weight of resin 2A, 1.1 parts by weight of Bontron E-81 (manufactured by Orient Chemical Industry Co., Ltd.) as CCA, and 3.3 parts by weight of carnauba wax (manufactured by NIPPON WAX CORPORATION) as the release agent were added, and thoroughly blended with a Henschel mixer 20B (manufactured by MITSUI MINING COMPANY, LIMITED), melt-kneaded with a two-shaft extruder (manufactured by TOSHIBA MACHINE CO., LTD.), cooled to normal temperature (about 25°C), pulverized with a pulverizer 200AFG (manufactured by HOSOKAWA MICRON CORPORATION), and classified with a classifier 100ATP (manufactured by HOSOKAWA MICRON CORPORATION), thereby mother particles having weight D50 of 8  $\mu$ m were obtained. To 100 parts by weight of the mother particles, 1 part by weight of silica RX200 (manufactured by Nippon Aerosil Co., Ltd.) was added and blended with a Henschel mixer 20B (manufactured by MITSUI MINING COMPANY, LIMITED), thereby a toner in Experimental Example 3A was obtained.

20.

#### Experimental Example 4A

To 14 parts by weight of master batch 1A, 90 parts by weight of resin 1A, 2 parts by weight of resin 2A, 1.1 parts by weight of Bontron E-81 (manufactured by Orient Chemical Industry Co., Ltd.) as CCA, and 3.3 parts by

weight of carnauba wax (manufactured by NIPPON WAX CORPORATION) as the release agent were added, and thoroughly blended with a Henschel mixer 20B (manufactured by MITSUI MINING COMPANY, LIMITED), melt-kneaded with a two-shaft extruder (manufactured by TOSHIBA MACHINE CO., LTD.), cooled to normal temperature (about 25°C), pulverized with a pulverizer 200AFG (manufactured by HOSOKAWA MICRON CORPORATION), and classified with a classifier 100ATP (manufactured by HOSOKAWA MICRON CORPORATION), thereby mother particles having weight D50 of 8  $\mu$ m were obtained. To 100 parts by weight of the mother particles, 1 part by weight of silica RX200 (manufactured by Nippon Aerosil Co., Ltd.) was added and blended with a Henschel mixer 20B (manufactured by MITSUI MINING COMPANY, LIMITED), thereby a toner in Experimental Example 4A was obtained.

#### Experimental Example 5A

To 14 parts by weight of master batch 1A, 10 parts by weight of resin 1A, 82 parts by weight of resin 2A, 1.1 parts by weight of Bontron E-81 (manufactured by Orient Chemical Industry Co., Ltd.) as CCA, and 3.3 parts by weight of carnauba wax (manufactured by NIPPON WAX CORPORATION) as the release agent were added, and thoroughly blended with a Henschel mixer 20B (manufactured



by MITSUI MINING COMPANY, LIMITED), melt-kneaded with a two-shaft extruder (manufactured by TOSHIBA MACHINE CO., LTD.), cooled to normal temperature (about 25°C), pulverized with a pulverizer 200AFG (manufactured by HOSOKAWA MICRON CORPORATION), and classified with a classifier 100ATP (manufactured by HOSOKAWA MICRON CORPORATION), thereby mother particles having weight D50 of 8 µm were obtained. To 100 parts by weight of the mother particles, 1 part by weight of silica RX200 (manufactured by Nippon Aerosil Co., Ltd.) was added and blended with a Henschel mixer 20B (manufactured by MITSUI MINING COMPANY, LIMITED), thereby a toner in Experimental Example 5A was obtained.

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#### Experimental Example 6A

To 14 parts by weight of master batch 1A, 80 parts by weight of resin 1A, 12 parts by weight of resin 2A, 1.1 parts by weight of Bontron E-81 (manufactured by Orient Chemical Industry Co., Ltd.) as CCA, and 5.6 parts by weight of carnauba wax (manufactured by NIPPON WAX CORPORATION) as the release agent were added, and thoroughly blended with a Henschel mixer 20B (manufactured by MITSUI MINING COMPANY, LIMITED), melt-kneaded with a two-shaft extruder (manufactured by TOSHIBA MACHINE CO., LTD.), cooled to normal temperature (about 25°C),

25

pulverized with a pulverizer 200AFG (manufactured by  
HOSOKAWA MICRON CORPORATION), and classified with a  
classifier 100ATP (manufactured by HOSOKAWA MICRON  
CORPORATION), thereby mother particles having weight D50 of  
5 8  $\mu\text{m}$  were obtained. To 100 parts by weight of the mother  
particles, 1 part by weight of silica RX200 (manufactured  
by Nippon Aerosil Co., Ltd.) was added and blended with a  
Henschel mixer 20B (manufactured by MITSUI MINING COMPANY,  
LIMITED), thereby a toner in Experimental Example 6A was  
10 obtained.

#### Experimental Example 7A

To 14 parts by weight of master batch 2A, 70 parts by  
weight of linear polyester resin (manufactured by Sanyo  
15 Chemical Industries Co., Ltd.; softening temperature ( $T_m$ ):  
105°C, glass transition temperature ( $T_g$ ): 68°C, weight  
average molecular weight ( $M_w$ ): 11,500), 22 parts by weight  
of crosslinked polyester resin (manufactured by Sanyo  
Chemical Industries Co., Ltd.; softening temperature ( $T_m$ ):  
20 144°C, glass transition temperature ( $T_g$ ): 60°C, weight  
average molecular weight ( $M_w$ ): 29,000), 1.1 parts by weight  
of Bontron E-81 (manufactured by Orient Chemical Industry  
Co., Ltd.) as CCA, and 3.3 parts by weight of carnauba wax  
(manufactured by NIPPON WAX CORPORATION) as the release  
25 agent were added, and thoroughly blended with a Henschel

mixer 20B (manufactured by MITSUI MINING COMPANY, LIMITED),  
melt-kneaded with a two-shaft extruder (manufactured by  
TOSHIBA MACHINE CO., LTD.), cooled to normal temperature  
(about 25°C), pulverized with a pulverizer 200AFG  
5 (manufactured by HOSOKAWA MICRON CORPORATION), and  
classified with a classifier 100ATP (manufactured by  
HOSOKAWA MICRON CORPORATION), thereby mother particles  
having weight D50 of 8  $\mu\text{m}$  were obtained. To 100 parts by  
weight of the mother particles, 1 part by weight of silica  
10 RX200 (manufactured by Nippon Aerosil Co., Ltd.) was added  
and blended with a Henschel mixer 20B (manufactured by  
MITSUI MINING COMPANY, LIMITED), thereby a toner in  
Experimental Example 7A was obtained.

The storage modulus  $G'$  (L1) in a linear region and  
15 the storage modulus  $G'$  (NL) in a nonlinear region at 180°C  
of each of these toners in Experimental Examples were  
measured, and the evaluation tests of non-offset region,  
fixing strength region, and transparency (HAZE value) as  
described above were performed by using each of these  
20 toners. The results obtained are shown in Table 1A below.

Table 1A

	G' (NL) (dyn/cm <sup>2</sup> )	G' (L1) / G' (NL)	Amount of release agent per 100 parts by weight of binder resin (parts by weight)	Low Temperature Offset	Minimum Temperature of Good Fixing Rate	Transparency (HAZE value)
Experimental Example 1A	120	8.3	3.2	A	A	A
Experimental Example 2A	380	19.7	3.2	B	B	A
Experimental Example 3A	200	12.5	3.2	A	A	A
Experimental Example 4A	80	4.8	3.2	All offset	All offset	All offset
Experimental Example 5A	600	21.5	3.2	C	C	A
Experimental Example 6A	110	10.4	5.5	A	A	C
Experimental Example 7A	700	21.4	3.2	C	C	C

Definition of descriptions "A", "B" and "C" in the above table are described in the following page.

Low temperature offset:

A: 160°C or less

B: Higher than 160°C and lower than 180°C

C: 180°C or higher

5 Minimum temperature of good fixing rate:

A: 160°C or less

B: Higher than 160°C and lower than 180°C

C: 180°C or higher

Transparency (HAZE value):

10 A: Less than 30

B: From 30 to 50

C: More than 50

As shown in Table 1A,  $G'$  (NL) in a nonlinear region  
15 at 180°C was 120 dyn/cm<sup>2</sup> in Experimental Example 1A, 380  
dyn/cm<sup>2</sup> in Experimental Example 2A, 200 dyn/cm<sup>2</sup> in  
Experimental Example 3A, 80 dyn/cm<sup>2</sup> in Experimental Example  
4A, 600 dyn/cm<sup>2</sup> in Experimental Example 5A, 110 dyn/cm<sup>2</sup> in  
Experimental Example 6A, and 700 dyn/cm<sup>2</sup> in Experimental  
20 Example 7A. The ratio of ( $G'$  (L1)) in a linear region to  
( $G'$  (NL)) in a nonlinear region at 180°C,  $G'$  (L1)/ $G'$  (NL)  
was 8.3 in Experimental Example 1A, 19.7 in Experimental  
Example 2A, 12.5 in Experimental Example 3A, 4.8 in  
Experimental Example 4A, 21.5 in Experimental Example 5A,  
25 10.4 in Experimental Example 6A, and 21.4 in Experimental

Example 7A.

As also shown in Table 1A, low temperature offset was 160°C or less in Experimental Examples 1A and 3A, and 180°C or less in Experimental Example 2A, thus any Experimental Example showed good result. In Experimental Example 4A, low temperature offset occurred in every measuring temperature, thus not good, low temperature offset occurred even at 180°C or higher in Experimental Examples 5A and 7A and were inferior, and Experimental Example 6A was 160°C or less and good result.

Minimum temperature of good fixing rate was 160°C or less in Experimental Examples 1A and 3A, lower than 180°C in Experimental Example 2A, thus every Experimental Example showed good results. In Experimental Example 4A, offset occurred in every measuring temperature and fixing rate could not be measured. In Experimental Examples 5A and 7A, fixing rate was 180° or more and inferior, and in Experimental Example 6A, fixing rate was 160°C or less, which was a good result.

With respect to transparency, HAZE values were less than 30 in Experimental Examples 1A to 3A, which were good results. In Experimental Example 4A, HAZE value could not be measured in every measuring temperature. In Experimental Example 5A, HAZE value was less than 30 and good result. In both Experimental Examples 6A and 7A, HAZE

value was greater than 50 and inferior.

From these results, it was confirmed that the toners in Experimental Examples 1A to 3A could attain the expected effects.

5

### Second invention

Experimental Examples of the toners of the second invention are described below.

The manufacture of the resins for the toners of the  
10 second invention used in Experimental Examples is described below.

#### Resin 1B

A mixture comprising 36 molar parts of neopentyl  
15 alcohol, 36 molar parts of ethylene glycol, 48 molar parts of 1,4-cyclohexanediol, 90 molar parts of dimethyl terephthalate, and 10 molar parts of phthalic anhydride was prepared.

A two-liter four-necked flask was equipped with a  
20 reflux condenser, a distillation column, a water separator, a nitrogen gas introducing pipe, a thermometer and a stirrer according to an ordinary method, charged with 1,000 g of the above mixture and 1 g of an esterification condensation catalyst, and esterification reaction was  
25 carried out with bleeding water and methanol generated at

180°C from the distillation column. At the point when water and methanol stopped bleeding from the distillation column, the distillation column was detached from the two-liter four-necked flask and a vacuum pump was connected to the four-necked flask. The pressure in the system was lowered to 5 mmHg or less and the reaction system was stirred at a rotary speed of 150 rpm at 200°C. Free diol generated by the condensation reaction was discharged from the system, and the thus-obtained reaction product was taken as resin 1B. Resin 1B had a softening temperature ( $T_m$ ) of 111°C, a glass transition temperature ( $T_g$ ) of 60°C, and a weight average molecular weight ( $M_w$ ) of 13,000.

#### Resin 2B

A mixture comprising 70 molar parts of resin 1B, 15 molar parts of 1,4-butanediol, and 15 molar parts of dimethyl terephthalate was prepared.

A two-liter four-necked flask was equipped with a reflux condenser, a distillation column, a water separator, a nitrogen gas introducing pipe, a thermometer and a stirrer according to an ordinary method, charged with 1,000 g of the above mixture and 1 g of an esterification condensation catalyst, and esterification reaction was carried out with bleeding water and methanol generated at 200°C from the distillation column. At the point when



water and methanol stopped bleeding from the distillation column, the distillation column was detached from the two-liter four-necked flask and a vacuum pump was connected to the four-necked flask. The pressure in the system was lowered to 5 mmHg or less and the reaction system was stirred at a rotary speed of 150 rpm at 220°C. Free diol generated by the condensation reaction was discharged from the system, and the thus-obtained reaction-product was taken as resin 2B. Resin 2B had a softening temperature (T<sub>m</sub>) of 149°C, a glass transition temperature (T<sub>g</sub>) of 64°C, and a weight average molecular weight (M<sub>w</sub>) of 28,000.

#### Master batch 1B

As the colorant, 30 wt.% of pigment Toner Magenta 6B (manufactured by Clariant Japan K.K.) was added to 70 wt.% of resin 2B. The mixture was thoroughly blended by a Henschel mixer 20B (manufactured by MITSUI MINING COMPANY, LIMITED) and kneaded with a continuous system twin roll kneader (manufactured by MITSUI MINING COMPANY, LIMITED). The kneaded product was coarsely pulverized to a particle size of about 2 mm with a pulverizer (manufactured by HOSOKAWA MICRON CORPORATION), thereby master batch 1B was obtained.

### Master batch 2B

As the colorant, 30 wt.% of pigment Toner Magenta 6B (manufactured by Clariant Japan K.K.) was added to 70 wt.% of resin 1B. The mixture was thoroughly blended by a Henschel mixer 20B (manufactured by MITSUI MINING COMPANY, LIMITED) and kneaded with a continuous system twin roll kneader (manufactured by MITSUI MINING COMPANY, LIMITED). The kneaded product was coarsely pulverized to a particle size of about 2 mm with a pulverizer (manufactured by HOSOKAWA MICRON CORPORATION), thereby master batch 2B was obtained.

### Experimental Example 1B

To 14 parts by weight of master batch 1B, 80 parts by weight of resin 1B, 12 parts by weight of resin 2B, 1.1 parts by weight of Bontron E-81 (manufactured by Orient Chemical Industry Co., Ltd.) as CCA, and 3.3 parts by weight of carnauba wax (manufactured by NIPPON WAX CORPORATION) as the release agent were added, and thoroughly blended with a Henschel mixer 20B (manufactured by MITSUI MINING COMPANY, LIMITED), melt-kneaded with a two-shaft extruder (manufactured by TOSHIBA MACHINE CO., LTD.), cooled to normal temperature (25°C), pulverized with a pulverizer 200AFG (manufactured by HOSOKAWA MICRON CORPORATION), and classified with a classifier 100ATP

(manufactured by HOSOKAWA MICRON CORPORATION), thereby  
mother particles having weight D50 of 8  $\mu$ m were obtained.  
To 100 parts by weight of the mother particles, 1 part by  
weight of silica RX200 (manufactured by Nippon Aerosil Co.,  
5 Ltd.) was added and blended with a Henschel mixer 20B  
(manufactured by MITSUI MINING COMPANY, LIMITED), thereby a  
toner in Experimental Example 1B was obtained.

#### Experimental Example 2B

10 To 14 parts by weight of master batch 1B, 60 parts by  
weight of resin 1B, 32 parts by weight of resin 2B, 1.1  
parts by weight of Bontron E-81 (manufactured by Orient  
Chemical Industry Co., Ltd.) as CCA, and 3.3 parts by  
weight of carnauba wax (manufactured by NIPPON WAX  
15 CORPORATION) as the release agent were added, and  
thoroughly blended with a Henschel mixer 20B (manufactured  
by MITSUI MINING COMPANY, LIMITED), melt-kneaded with a  
two-shaft extruder (manufactured by TOSHIBA MACHINE CO.,  
LTD.), cooled to normal temperature (25°C), pulverized with  
20 a pulverizer 200AFG (manufactured by HOSOKAWA MICRON  
CORPORATION), and classified with a classifier 100ATP  
(manufactured by HOSOKAWA MICRON CORPORATION), thereby  
mother particles having weight D50 of 8  $\mu$ m were obtained.  
To 100 parts by weight of the mother particles, 1 part by  
25 weight of silica RX200 (manufactured by Nippon Aerosil Co.,

Ltd.) was added and blended with a Henschel mixer 20B (manufactured by MITSUI MINING COMPANY, LIMITED), thereby a toner in Experimental Example 2B was obtained.

5

#### Experimental Example 3B

To 14 parts by weight of master batch 1B, 70 parts by weight of resin 1B, 22 parts by weight of resin 2B, 1.1 parts by weight of Bontron E-81 (manufactured by Orient Chemical Industry Co., Ltd.) as CCA, and 3.3 parts by weight of carnauba wax (manufactured by NIPPON WAX CORPORATION) as the release agent were added, and thoroughly blended with a Henschel mixer 20B (manufactured by MITSUI MINING COMPANY, LIMITED), melt-kneaded with a two-shaft extruder (manufactured by TOSHIBA MACHINE CO., LTD.), cooled to normal temperature (25°C), pulverized with a pulverizer 200AFG (manufactured by HOSOKAWA MICRON CORPORATION), and classified with a classifier 100ATP (manufactured by HOSOKAWA MICRON CORPORATION), thereby mother particles having weight D50 of 8  $\mu$ m were obtained.

20 To 100 parts by weight of the mother particles, 1 part by weight of silica RX200 (manufactured by Nippon Aerosil Co., Ltd.) was added and blended with a Henschel mixer 20B (manufactured by MITSUI MINING COMPANY, LIMITED), thereby a toner in Experimental Example 3B was obtained.

25

#### Experimental Example 4B

To 14 parts by weight of master batch 2B, 92 parts by weight of resin 1B, 1.1 parts by weight of Bontron E-81 (manufactured by Orient Chemical Industry Co., Ltd.) as CCA, and 3.3 parts by weight of carnauba wax (manufactured by NIPPON WAX CORPORATION) as the release agent were added, and thoroughly blended with a Henschel mixer 20B (manufactured by MITSUI MINING COMPANY, LIMITED); melt-kneaded with a two-shaft extruder (manufactured by TOSHIBA MACHINE CO., LTD.), cooled to normal temperature (25°C), pulverized with a pulverizer 200AFG (manufactured by HOSOKAWA MICRON CORPORATION), and classified with a classifier 100ATP (manufactured by HOSOKAWA MICRON CORPORATION), thereby mother particles having weight D50 of 8  $\mu$ m were obtained. To 100 parts by weight of the mother particles, 1 part by weight of silica RX200 (manufactured by Nippon Aerosil Co., Ltd.) was added and blended with a Henschel mixer 20B (manufactured by MITSUI MINING COMPANY, LIMITED), thereby a toner in Experimental Example 4B was obtained.

#### Experimental Example 5B

To 14 parts by weight of master batch 1B, 30 parts by weight of resin 1B, 62 parts by weight of resin 2B, 1.1 parts by weight of Bontron E-81 (manufactured by Orient

Chemical Industry Co., Ltd.) as CCA, and 3.3 parts by weight of carnauba wax (manufactured by NIPPON WAX CORPORATION) as the release agent were added, and thoroughly blended with a Henschel mixer 20B (manufactured by MITSUI MINING COMPANY, LIMITED), melt-kneaded with a two-shaft extruder (manufactured by TOSHIBA MACHINE CO., LTD.), cooled to normal temperature (25°C), pulverized with a pulverizer 200AFG (manufactured by HOSOKAWA MICRON CORPORATION), and classified with a classifier 100ATP (manufactured by HOSOKAWA MICRON CORPORATION), thereby mother particles having weight D50 of 8  $\mu$ m were obtained. To 100 parts by weight of the mother particles, 1 part by weight of silica RX200 (manufactured by Nippon Aerosil Co., Ltd.) was added and blended with a Henschel mixer 20B (manufactured by MITSUI MINING COMPANY, LIMITED), thereby a toner in Experimental Example 5B was obtained.

#### Experimental Example 6B

To 14 parts by weight of master batch 1B, 80 parts by weight of resin 1B, 12 parts by weight of resin 2B, 1.1 parts by weight of Bontron E-81 (manufactured by Orient Chemical Industry Co., Ltd.) as CCA, and 5.6 parts by weight of carnauba wax (manufactured by NIPPON WAX CORPORATION) as the release agent were added, and thoroughly blended with a Henschel mixer 20B (manufactured

by MITSUI MINING COMPANY, LIMITED), melt-kneaded with a two-shaft extruder (manufactured by TOSHIBA MACHINE CO., LTD.), cooled to normal temperature (25°C), pulverized with a pulverizer 200AFG (manufactured by HOSOKAWA MICRON CORPORATION), and classified with a classifier 100ATP (manufactured by HOSOKAWA MICRON CORPORATION), thereby mother particles having weight D50 of 8  $\mu$ m were obtained. To 100 parts by weight of the mother particles, 1 part by weight of silica RX200 (manufactured by Nippon Aerosil Co., Ltd.) was added and blended with a Henschel mixer 20B (manufactured by MITSUI MINING COMPANY, LIMITED), thereby a toner in Experimental Example 6B was obtained.

The storage modulus  $G'$  (L2) in a linear region and the storage modulus  $G'$  (NL) in a nonlinear region at 180°C of each of these toners in Experimental Examples were measured, and the evaluation tests of non-offset region, fixing strength region, and transparency (HAZE value) as described above were performed by using each of these toners. The results obtained are shown in Table 1B below.

Table 1B

	G' (L2) (dyn/cm <sup>2</sup> )	G' (L2)/G' (NL)	Amount of release agent per 100 parts by weight of binder resin (parts by weight)	Hot Offset	Minimum Temperature of Good Fixing Rate	Transparency (HAZE value)
Experimental Example 1B	420	3.5	3.2	B	A	A
Experimental Example 2B	1,960	7	3.2	A	B	A
Experimental Example 3B	1,000	5	3.2	A	A	A
Experimental Example 4B	224	2.8	3.2	All offset	All offset	All offset
Experimental Example 5B	3,280	8.2	3.2	A	C	A
Experimental Example 6B	407	3.7	5.5	A	B	C

Definition of descriptions "A", "B" and "C" in the above Table are described in the following page.



Hot offset:

A: 200°C or higher

B: Higher than 180°C and lower than 200°C

C: 180°C or lower

5 Minimum temperature of good fixing rate:

A: 160°C or less

B: Higher than 160°C and lower than 180°C

C: 180°C or higher

Transparency (HAZE value):

10 A: Less than 30

B: From 30 to 50

C: More than 50

As shown in Table 1B,  $G'$  (L2) in a linear region at  
15 180°C was 420 dyn/cm<sup>2</sup> in Experimental Example 1B, 1,960  
dyn/cm<sup>2</sup> in Experimental Example 2B, 1,000 dyn/cm<sup>2</sup> in  
Experimental Example 3B, 224 dyn/cm<sup>2</sup> in Experimental  
Example 4B, 3,280 dyn/cm<sup>2</sup> in Experimental Example 5B, and  
407 dyn/cm<sup>2</sup> in Experimental Example 6B. The ratio of ( $G'$   
20 (L2)) in a linear region to ( $G'$  (NL)) in a nonlinear region  
at 180°C,  $G'$  (L2)/ $G'$  (NL) was 3.5 in Experimental Example  
1B, 7 in Experimental Example 2B, 5 in Experimental Example  
3B, 2.8 in Experimental Example 4B, 8.2 in Experimental  
Example 5B, and 3.7 in Experimental Example 6B.

25 As also shown in Table 1B, hot offset was higher than

180°C in Experimental Example 1B, and 200°C or more in Experimental Examples 2B and 3B, thus any Experimental Example showed good result. In Experimental Example 4B, hot offset occurred in every measuring temperature, thus not good, and both Experimental Examples 5B and 6B were 200°C or more and good results.

Minimum temperature of good fixing rate was 160°C or less in Experimental Examples 1B and 3B, lower than 180°C in Experimental Example 2B, thus every Experimental Example showed good results. In Experimental Example 4B offset occurred in every measuring temperature and fixing rate could not be measured. In Experimental Example 5B fixing rate was 180°C or more and inferior, and fixing rate was 160°C or less in Experimental Example 6B, which was good result.

With respect to transparency, HAZE values were less than 30 in Experimental Examples 1B to 3B, which were good results. In Experimental Example 4B HAZE value could not be measured in every measuring temperature. In Experimental Example 5B, HAZE value was less than 30 and good result. In Experimental Example 6B, HAZE value was greater than 50, which was inferior.

From these results, it was confirmed that the toners in Experimental Examples 1B to 3B could attain the expected effects.

In the toner of the first invention having such a constitution, since in step strain measurement of from a linear region to a nonlinear region of viscoelastic characteristics, the ratio of the storage modulus ( $G' (L1)$ ) in a linear region to the storage modulus ( $G' (NL)$ ) in a nonlinear region at 180°C,  $G' (L1)/G' (NL)$  is set from 5 to 20, and  $G' (NL)$  is set from 100 to 400 dyn/cm<sup>2</sup>; a linear region and a nonlinear region of dynamic viscoelastic characteristics of the strain dependency of the toner are effectively utilized in fixation by heating, thus a toner more conformable to actual behavior of toner can be obtained.

Therefore, according to the toner of the first invention, melting of the toner in fixing nip is performed smoothly and it becomes possible to effectively improve low temperature fixing ability and offset resistance of the toner.

In particular, when the content of a release agent is more than 4 parts by weight per 100 parts by weight of the binder resin, transparency is hindered, so that transparency can be improved by setting the content of a release agent at 4 parts by weight or less per 100 parts by weight of the binder resin.

According to the image-forming apparatus of the first

invention, a high quality toner image of oil-less and having good transparency can be formed while maintaining low temperature fixing ability and preventing offset by organically combining a toner improved in low temperature fixing ability and offset resistance as described above, in addition, a toner improved in transparency, with an oil-less two-roller fixing unit.

In the toner of the second invention having such a constitution, since the storage modulus ( $G' (L2)$ ) in a linear region at 180°C is from 400 to 2,000 dyn/cm<sup>2</sup> in step strain measurement of from a nonlinear region to a linear region of viscoelastic characteristics, a linear region and a nonlinear region of dynamic viscoelastic characteristics of the strain dependency of the toner are effectively utilized in fixation by heating, thus a toner more conformable to actual behavior of toner can be obtained.

Therefore, according to the toner of the second invention, elasticity after transiting fixing nip can be ensured, and it becomes possible to effectively improve hot offset resistance.

In particular, when the ratio of the storage modulus ( $G' (L2)$ ) in a linear region to the storage modulus ( $G' (NL)$ ),  $G' (L2)/G' (NL)$ , is from 3 to 8, fixing ability is improved and at the same time good hot offset resistance can be obtained.

Further, when the content of a release agent in a toner is more than 4 parts by weight per 100 parts by weight of the binder resin, transparency is hindered, so that transparency can be improved by setting the content of  
5 a low melting substance at 4 parts by weight or less.

According to the image-forming apparatus of the second invention, a high quality toner image of oil-less and having good transparency can be formed while  
maintaining good fixing ability and preventing hot offset  
10 by organically combining a toner improved in low temperature fixing ability and hot offset resistance as described above, in addition, a toner improved in transparency, with an oil-less two-roller fixing unit.

While the present invention has been described in  
15 detail and with reference to specific embodiments thereof, it will be apparent to one skilled in the art that various changes and modifications can be made therein without departing the spirit and scope thereof.

The present application is based on Japanese Patent  
20 Applications No. 2003-053833 and 2003-053834, both thereof filed on February 28, 2003, and the contents thereof are incorporated herein by reference.